INTERAVIA

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with Electronics Supplement

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Volume XV

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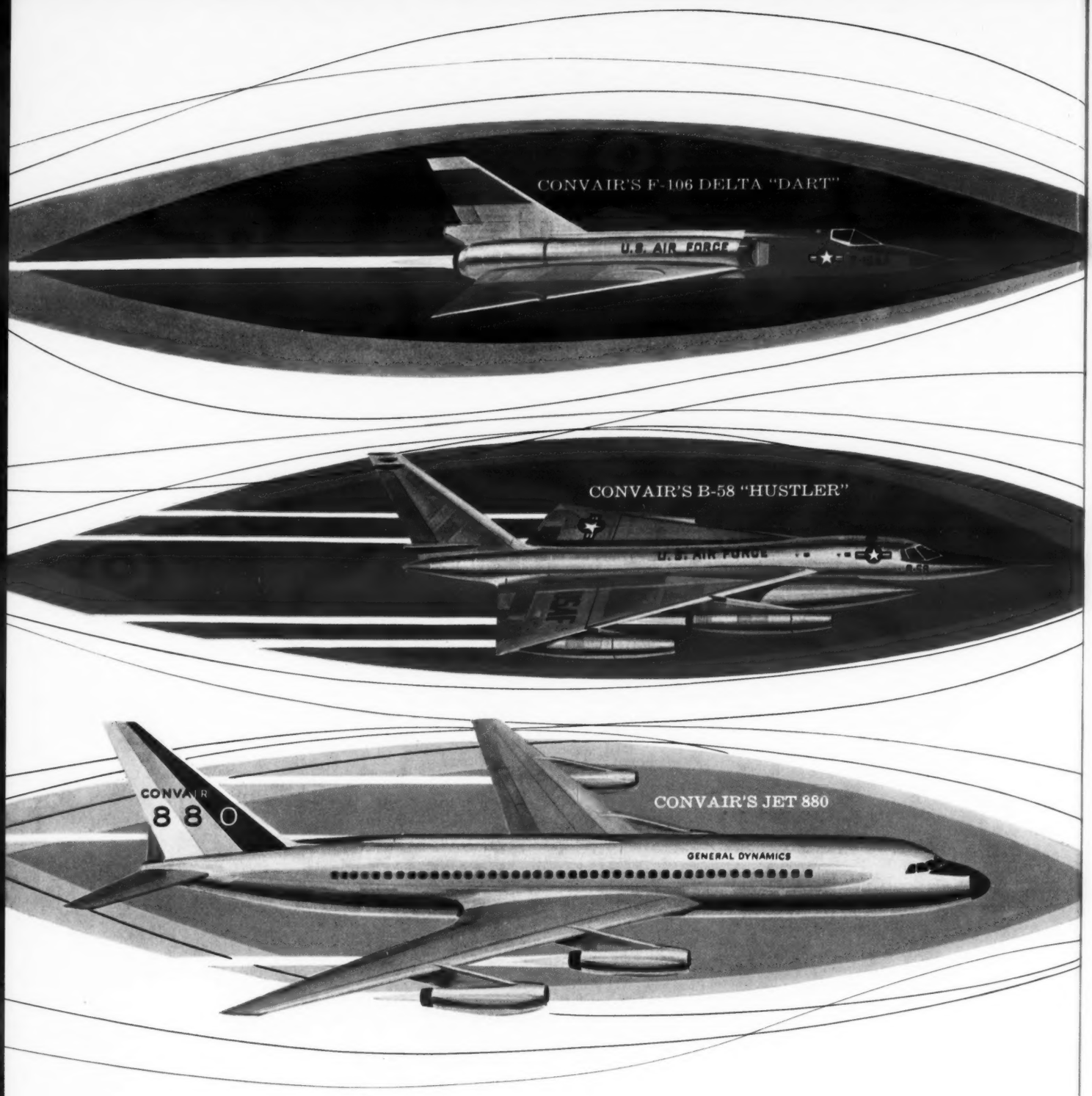
Single-Seat Combat Aircraft • F-105D Weapons System

No. 3 / 1960



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Volume XV

INTERAVIA

March 1960

WORLD REVIEW OF AVIATION AND ASTRONAUTICS

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Front cover : Convair 880 jets, produced by the Convair Division of General Dynamics Corporation, will be joining the Boeing 707s, de Havilland *Comet 4s* and Douglas DC-8s on the world's air routes during 1960 and 1961.

Among the obligations of an airline the comfort of passengers is second only to their safety.

Sabena is proud of the achievement of one of its engineers, Mr. François Braun, who has designed a new type of seat. This has been built in the company's workshops and put through the most rigorous tests; it increases not only the comfort of travellers, but also their safety. The Braun seat automatically assumes a horizontal position when subjected to a given deceleration, particularly in the case of a hard landing.

The Belgian Aeronautical Administration has recently certificated this new seat. During laboratory tests at Haren, near Brussels, a resistance to deceleration stress of 20 g was recorded, corresponding to 3,750 lb per passenger.

The Braun seat, which will equip the first-class cabins of Sabena's Boeing Intercontinentals, has also aroused the interest of Air France, which has ordered seven lots of 36 seats.

The USAF is also considering using the Braun seat, which it will shortly be subjecting to dynamic tests.

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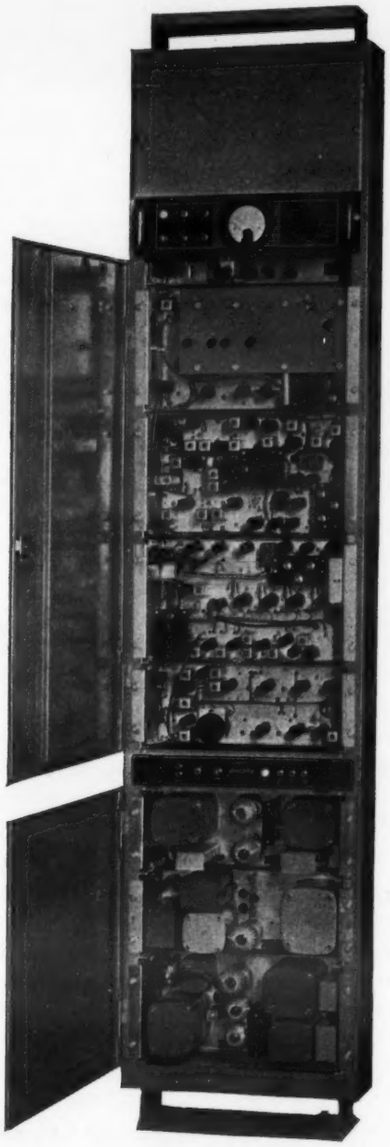

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Mobil's new jet fuel hydrant servicer in combination with Mobiljet fuels delivers cleaner and better fuel faster and more safely than ever before.

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DRAMATIC ANSWER TO THE AIR CARGO DILEMMA

Many air carriers, striving to answer perplexing questions presented by a growing air cargo industry, are facing a basic decision: should they convert outmoded piston engine passenger equipment and put it on to air cargo routes? Should they order proposed cargo jets with 100,000 lb. payloads? Should they wait for further turbo-fan evaluations before making their air cargo plane commitments?

Canadair's Forty Four, offers a simple, practical answer to these vital questions. It is an optimum-size, all-new, all-cargo turbo-prop airplane that, in terms of productivity, is vastly superior to converted piston engine equipment, and one that offers, in comparison with the big jets, a payload capacity that is not unrealistically high for profitable operations during the 1960's. Furthermore, the Forty Four suffers little or no operating penalties due to runway limitations, and there will be no community noise problems.

The Canadair Forty Four has a productivity two to three times that of converted piston aircraft, at the same cost per airplane mile, and has a profit potential that will quickly recover any losses on disposal of piston engine aircraft now being used or contemplated for cargo usage. On the other hand, the Forty Four with a payload capacity of 65,000 lbs. and low break-even point is ideally matched to the natural expansion of the cargo market and will begin immediately to operate at profitable load factors.

The Canadair Forty Four is flying now and is in production for the three largest all-cargo carriers in the United States, and can be introduced into existing fleets as early as January 1961.

The Canadair Forty Four can operate in and out of all airports presently used by four-engined piston-powered aircraft. For example, at such an important airport as Midway, in Chicago, with only 6400′ runways, the Forty Four can take off with 90% of its maximum payload and fly non-stop to San Francisco.

Sophisticated design features, including swing tail and integral cargo handling equipment, slash direct and indirect costs.

Step-by-step savings and economies inherent in the Canadair Forty Four, combined with its very attractive price, let precious capital dollars work for better return quicker than other "proposed" equipment.

Thus General Dynamics Corporation's Canadian subsidiary, Canadair, the specialist in air cargo, proposes the Forty Four as the answer to air cargo's biggest dilemma.

Principal Features of the Canadair Forty Four

1. Low prime cost—less than ⅔ the price of proposed jets.
2. Low operating costs—estimated at $1.30 per aircraft mile, and less than 4¢ per ton mile.
3. Right size for the 1960's—its present payload capacity is ideally matched to forecasted requirements.
4. No community noise problems—confirmed during present flight testing.
5. No airport or runway limitations—every major airport open to the Canadair Forty Four.
6. Growth potential—able to grow with the market.
7. Available for delivery in January 1961.

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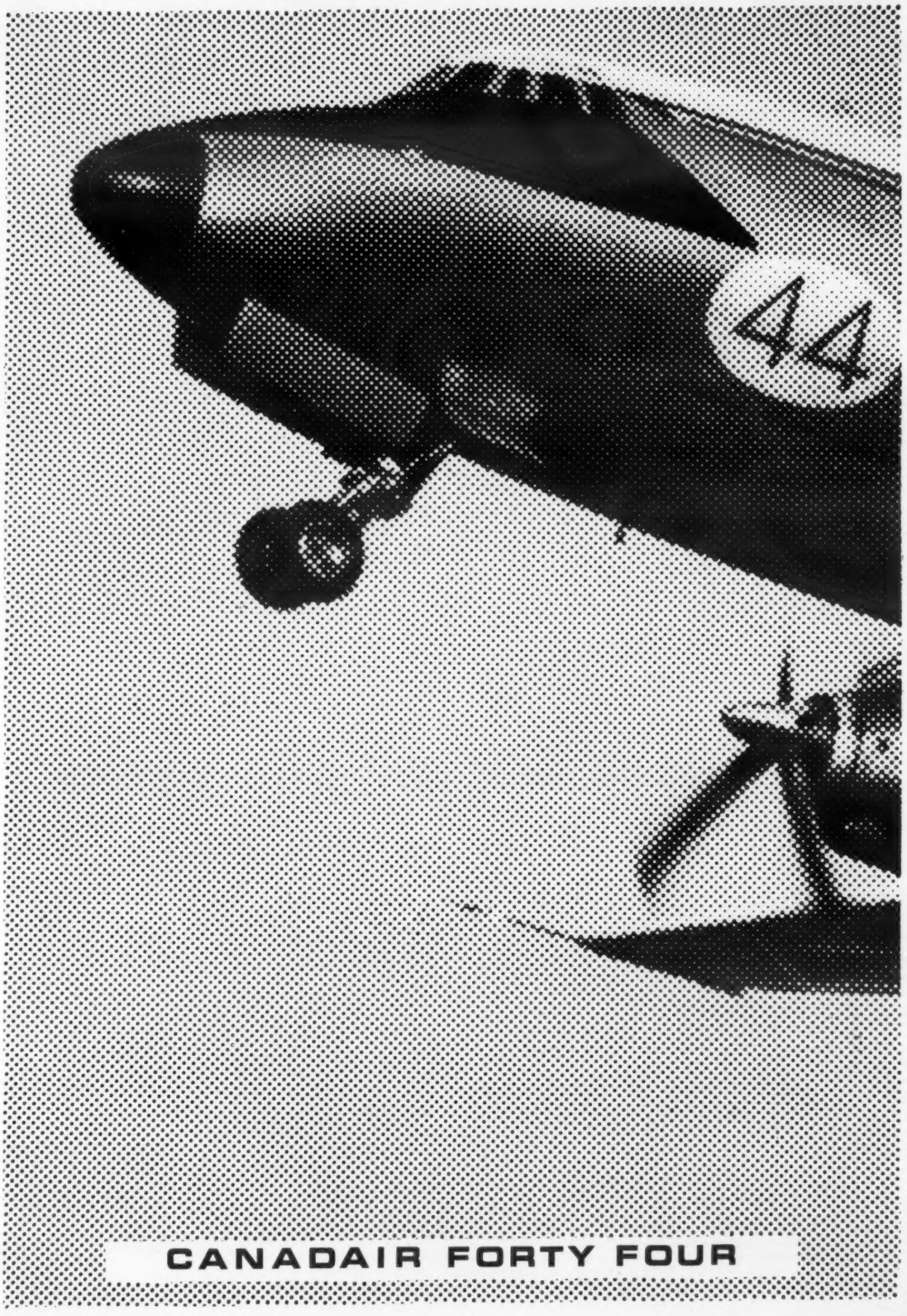
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This matched power team consisting of the Allison Model 501 Prop-jet Engines and Aeroproducts Turbo-propellers is delivering top performance and economy to 15 of the world's airlines. Allison-powered Lockheed Electras and C-130 military transports are acquiring flight experience at a rate exceeding 125,000 hours per month. Enthusiastic public acceptance is reflected in continuing high load factors.

This Allison power package is the workhorse of the jet age. The 501's power-to-weight ratio is 2.1 h.p. per pound —best of today's prop-jets. This design advantage, combined with efficient use of low-cost fuel, extends flight range, permits greater aircraft utilization and lowers operating cost to operators everywhere.

The immediate power response of the Allison 501 Engine permits shorter take-offs and landings . . . instantly provides adequate power for any requirement. The reverse thrust of the Aeroproducts Turbo-propellers provides braking action for positive stops—even under extreme weather conditions—performance ideally suited to operators serving smaller airports under a variety of weather conditions.

Allison-powered Lockheed C-130

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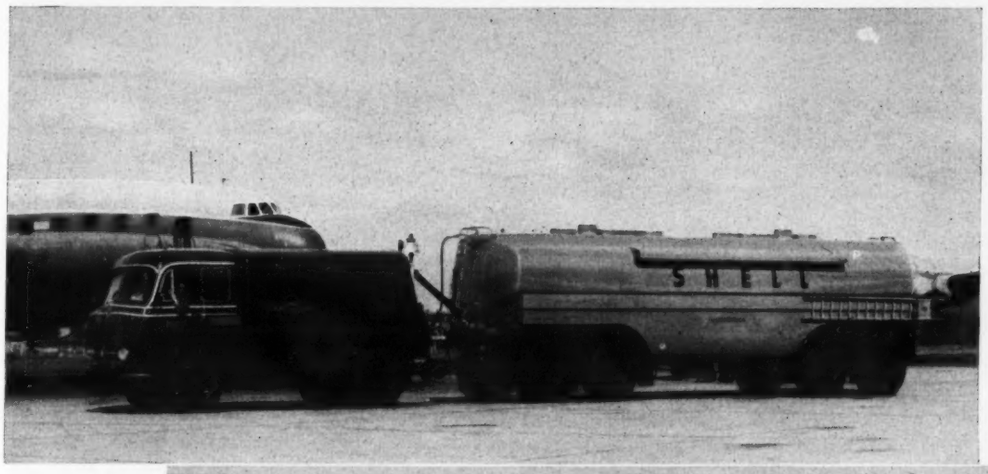

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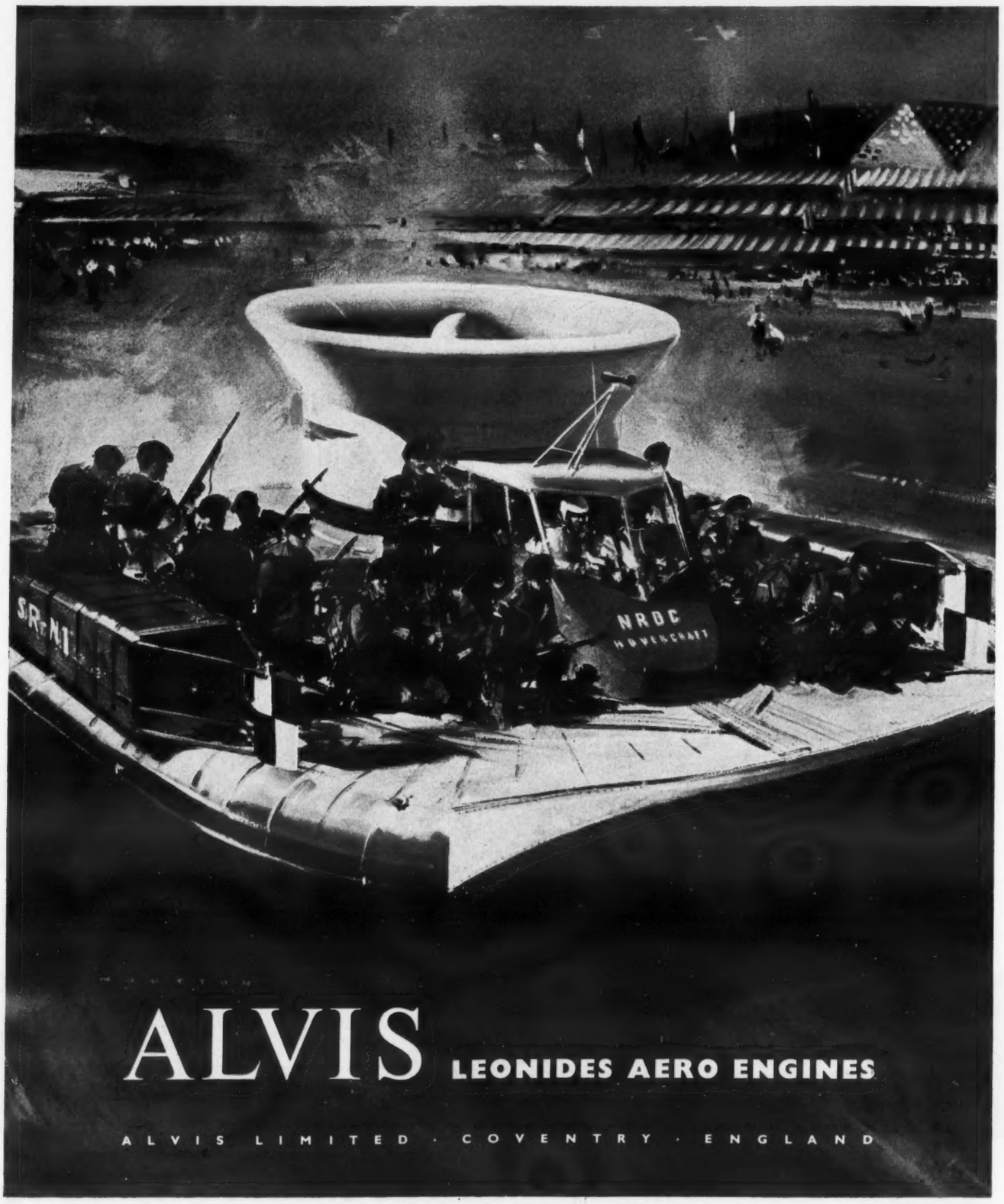

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INTERAVIA AIR LETTER reports...*

Rationalization of the British Aircraft Industry

The following new developments have taken place in the "rationalization" of the British aircraft industry since the article on p. 288 was written :

On February 15th *Minister of Aviation Duncan Sandys* presented a Government statement on the industry to the House of Commons. Highlights from the speech were: 1) the new amalgamation/merger setup within the industry has full official approval; 2) to aid the industry's export business, the Government will share development costs on certain projects, recouping some of the money thus expended by drawing a percentage of earnings from successful aircraft "in proportion to the risks borne"; assistance will be granted in financing the necessary tooling, and also in production to provide "off-the-shelf" availability for overseas customers; 3) the Government will also subsidize some testing and airline route proving operations, to help remove any snags in new aircraft. Farnborough and Boscombe Down may be used for civil flight testing, and the Government will provide more funds for civil research and development as military work in this field runs out.

The Minister, however, declined to give any hint as to how much money will be available or how it will be distributed. Talks, he said, are already in progress with the industry heads, and until they are concluded no details will be made public. Except in the case of special requirements or for reasons of public policy, support will be given only to the five big groups (see main article).

Commenting on the statement, *Interavia's* London Editor writes that support will almost certainly be forthcoming for both the DH.121 and the VC.11 designs, despite the fact that they are in many ways competing aircraft. Also, although no final decision has yet been taken on whether Britain should build a supersonic airliner, feasibility study contracts are expected to be awarded to both the Hawker Siddeley Group and the English Electric-Vickers-Bristol group during the next few months. Looking further ahead, full research and development backing will be given to VTOL systems (with particular interest being shown in the Hawker P.1127 model) and to blind landing systems.

Meanwhile informal discussions have been going on between *Rolls-Royce* and *English Electric* regarding a possible take-over of Napier's aircraft engine activities. If agreement is reached, Rolls-Royce would probably develop and produce the Napier *Eland* turboprop and *Gazelle* turboshaft engine, while Napier would concentrate on diesels, Spraymat and turbo-blowers, etc.

Handley Page has also reportedly been having talks with *Hunting* on a possible link-up. This, despite the fact that Hunting Aircraft has been discussing going in with the English Electric-Vickers-Bristol group.

The Fairey Company is reported as likely to retain its guided weapon division and overhaul and maintenance of the *Jindivik* target drone.

The English Electric Co.'s *Aircraft Equipment Division* will not be included in the English Electric-Vickers-Bristol merger.

Finally, the great majority of the shareholders of both *de Havilland Holdings* and the *Blackburn Group* have now accepted the Hawker Siddeley take-over offer.

●

The IATA special Traffic Conference opened in Paris on February 23rd to discuss fare problems unresolved at last October's Honolulu Conference, namely, the rates which are to apply between Europe, the Far East, Africa and Australasia, within Australasia, and across the Pacific and North Atlantic. The first step will probably be an emergency resolution extending the existing fare structure for a period of about two months from April 1st; this would give the carriers more time to agree a new schedule of fares. The Conference will also have to consider the question of jet surcharges on routes other than the North Atlantic; North Atlantic operators have agreed to drop the surcharge as from the first of this month. Also up for discussion will be the question of the number of classes to be offered on international routes and cabin layouts; the introduction of economy rates has led to a reduction of tourist class business, and a trend towards a two-class structure.

●

Air Union still seems as far as ever from practical realization. Although the Transport Ministers of Belgium, France, Italy and West Germany, meeting in Paris on February 19th, reached a measure of agreement on the legal framework of the organization, further studies are to be carried out on the international legal problems and the group's economic organization and financial system. In addition, Alitalia and Lufthansa are claiming that their growth rates merit upward revision of their quotas of Air Union traffic.

●

Finnair took delivery of the first of three SE.210 *Caravelle IAs* at Toulouse on February 21st; the second and third are due for delivery in March and April. The Finnair *Caravelles* have a 16 first class and 57 tourist class layout, and will be introduced on the carrier's Helsinki-Copenhagen-Cologne-Frankfurt and Helsinki-Stockholm routes with effect from April 1st.

●

Western Air Lines has resolved its study of medium-haul jet aircraft and has ordered three Boeing 720s, with an option on a fourth.

●

Garuda Indonesian Airways is giving serious consideration to the Canadair 540 and is negotiating a possible deal with Canadair. Garuda's present fleet includes 11 Convair 340/440s and eight Convair 240s; the carrier wants to trade in the eight 240s against an unspecified number of 540s powered by Napier *Eland* propeller turbines.

Radio Corporation of America has received a $474,831,000 follow-on contract from the U.S. Air Force for work on the U.S. Ballistic Missile Early Warning System (BMEWS). The new award brings the total amount earmarked for BMEWS to over $700 million. This sum includes $180 million allocated to the U.S. Army Corps of Engineers for construction of facilities, and $66,768,000 to Western Electric Company for communications. The first BMEWS station at Thule, Greenland, is expected to become operational this year and a second at Clear, Alaska, in 1961. The U.S. and the U.K. have agreed on the location of the third station, which is to be at Fylingdales Moor in Yorkshire. A recent General Electric statement said that the BMEWS installations will have up to a total of four parabolic antennas, each measuring 165 feet in height and 400 feet in length.

Donald W. Douglas, Jr., President of Douglas Aircraft Co. (left) and Georges Héreil, President of Sud-Aviation, after signing the technical cooperation agreement (cf. page 318 of this issue). It has since been revealed that Douglas and Sud-Aviation will also collaborate in developing a *Super DC-8* for 200 passengers and a short-range version of the *Caravelle*.

The U.S. Air Force's 320th Bomber Wing (stationed at March AFB, Calif.), which comprises four B-47 *Stratojet* squadrons with 45 aircraft and 2,000 personnel, will be disbanded next September in keeping with Strategic Air Command's policy of maintaining only one bomber wing at any one strategic base. The 22nd Bomber Wing, which will remain at March AFB, will reportedly change over from B-47s to either eight-jet Boeing B-52 intercontinental bombers or Convair B-58s.

●

The Bristol Aeroplane Company celebrated its fiftieth anniversary on February 19th. Founded in 1910 by Sir George White, the then British & Colonial Aircraft Company began modestly with a capital of £25,000; nevertheless, large numbers of Bristol aircraft, notably the F2B fighter and the *Braemar* bomber, saw service during World War I. — The Company adopted its present title in 1919, and in 1920 the Aero Engine Department was formed. In 1929 the RAF chose the *Bulldog* as its standard fighter, and in 1935 Bristol developed the *Britain First* monoplane, later to be developed into the *Blenheim* bomber. During World War II Bristol aircraft and engines were in service in nearly all theatres of war. — After the war Bristol diversified its activities, engaging in helicopter, guided missile and motor car production. In 1956 the company reorganized, creating Bristol Aircraft, Bristol Aero Engines and Bristol Motor Cars as its subsidiaries. In 1959 Bristol Aero Engines amalgamated with Armstrong Siddeley Engines to form Bristol Siddeley Engines ; and in January this year Bristol Aircraft amalgamated with English Electric Aviation and Vickers-Armstrongs Aircraft. Current Bristol

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projects include the Type 188 research aircraft and the BE-53 and BE-58 ductedfan engines.

●

Boeing Airplane Co. has announced that the U.S. Federal Aviation Agency has granted a full C of A to the 707-420 with Rolls-Royce *Conway RCo.12* engines. The type is certificated at 312,000 lb taxi weight, 311,000 lb take-off weight and 207,000 lb max. landing weight. The FAA certification precedes delivery of Air-India's first 707-420 which made a record non-stop flight from London to Bombay on February 21st. BOAC's Boeing 707-436 will not be certificated until flight testing is completed on the various modifications requested by the U.K. Air Registration Board.

●

Under the NAMCO production programme for the YS-11 turboprop medium transport Mitsubishi Heavy-Industries, Kawasaki Aircraft and Fuji Heavy Industries will cooperate in the production of major components; Shin Meiwa Industry and Japan Aircraft will produce minor components; and Showa Aircraft will be engaged in the production of machine tools. NAMCO says that the cost per aircraft will be of the order of 360 million yen ($1 million), and that the company hopes to find an export market among the south-east Asian countries. — Manufacture of two YS-11 prototypes will begin later this year under a project financed by a 750 million yen ($2.1 million) Government investment covered in the fiscal 1960 budget plan, and 600 million yen ($1.6 million) in private funds. Production of machine tools will begin in May, followed by first component production beginning in October; assembly of the prototypes will begin in March, 1961, and test flights of the first prototype are due in October, 1961. NAMCO has signed a formal contract with Rolls-Royce for five *RDa.10* turboprop engines, at a price of $831,600 (£297,000). If flight testing is successful, NAMCO plans to produce two aircraft per month from 1962.

●

Canadair Ltd., of Montreal, and the Department of Defence Production have reportedly disagreed on the award of subcontracts, and this is said to be the reason for the delay in the signature of the contract for 200 CF-104 airframes to be built at Canadair. Canadair has already subcontracted about $25 million worth of CF-104 work to Canadian companies, but the Department of Defence Production apparently feels that the proportion should be higher. Canadair considers its bid to be the lowest possible to still show a profit, and the company is baulking at paying more than planned for subcontracted components.

●

Swissair will inaugurate Douglas DC-8 service to New York with effect from June 6th; initial frequency will be three flights weekly, increasing to 12 flights weekly from September 10th. *From June 6th :* three flights weekly Zurich-Geneva-New York (with a fuel stop at Shannon — Geneva airport runway extensions will not be completed until the end of June). Eastbound, twice weekly New York-Geneva-Zurich and once New York-Cologne-Zurich. *From July 1st :* four times weekly Zurich-Geneva-New York (no fuel stop). Eastbound, twice weekly New York-Geneva-Zurich, once New York-Cologne-Zurich, and once New York-Zurich non-stop. *From July 26th :* nine flights weekly. Westbound, six Zurich-Geneva-New York, two Zurich-Geneva-Lisbon-New York (with fuel stop in the Azores), and once Zurich-Cologne-New York (with fuel stop). Eastbound, one New York-Zurich non-stop, three New York-Geneva-Zurich, two New York-Cologne-Zurich, and three New York-Lisbon-Geneva-Zurich. *From September 10th :* 12 flights weekly. Westbound, seven Zurich-Geneva-New York, two Zurich-Cologne-New York (with fuel stop), three Zurich-Lisbon-New York (with fuel stop). Eastbound, two New York-Zurich non-stop, two New York-Geneva-Zurich, five New York-Lisbon-Geneva-Zurich, and three New York-Cologne-Zurich.

●

Lufthansa Boeing 707 *Intercontinental* service on the Frankfurt-New York route, scheduled for inauguration on March 17th, will be operated at an initial frequency of four flights weekly, to be increased to seven services weekly with effect from April 1st. Lufthansa's Boeing 707s have a 24 first class and 120 economy class passenger layout. From mid-May the carrier will also introduce the Boeing 707 on the Frankfurt-Chicago run with a frequency of two flights weekly. A parallel Lockheed *Super Constellation* service Frankfurt-Düsseldorf-Montreal-Chicago will be operated once weekly. Also in mid-May Lufthansa will inaugurate a new twice-weekly Boeing 707 service on the route Frankfurt-Paris-Montreal-San Francisco.

●

Goodyear Aircraft Corporation is reportedly considering the construction of nuclear-powered blimps to perform a variety of duties, including missile carrying and launching.

●

The first Potez 4E flat four engines will be ready for delivery by the end of 1960. The engines exist in two versions: the 4E.00 with 90 h.p. take-off rating, and the 4E.02 with 105 h.p. take-off rating. The 4E.02 has successfully concluded a series of endurance tests at the CEMH (Centre d'Essais Moteurs et Hélices) Saclay facility prior to official type certification tests, which are to begin shortly, and flight testing has begun on a Jodel D.100 *Ambassadeur*. The 4E.00 received certification some time ago and has since completed a further 586 hours.

●

The first prototype of a new STOL touring aircraft, designated RF 1, is nearing completion at Rhein-Flugzeugbau GmbH, Krefeld. The six-seat RF 1 is powered by two 250 h.p. Lycoming engines, which drive one pusher propeller. An automatic centrifugal clutch and a freewheel clutch enable each engine to be run separately; if a fault develops in one engine, it is switched off by an automatic device. The RF 1, which is of all-metal construction and makes extensive use of plastic reinforced with fibreglass, has a ducted propeller, wing with U-shaped centre section, and electrically retractable nosewheel undercarriage. Wing span is 43.96 ft; length 42.9 ft; cruising speed approximately 140 knots; range approximately 400 n.m., or 810 n.m. with external tanks.

●

The Merckle SM 67 five-seat turbine-powered helicopter (1 × Turboméca *Artouste* shaft turbine) should complete its flight tests by the end of the year. In the meantime further State contracts have been signed for the continuation of development and the installation of the more powerful *Artouste IIC* turbine. Flight tests on the SM 67 have so far been conducted with the *Artouste IIB*.

●

The U.S. Air Force may order work to begin soon on an advanced supersonic VTOL fighter. Major-General James Ferguson, Vice-Commander of the Air Research and Development Command, said an undisclosed sum is provided for the development of this aircraft in the budget for fiscal 1961. Bell, Lockheed, Republic and other firms as yet undisclosed have worked out projects or have actually started building prototypes.

Plans for the development of a Japanese-designed ASW flying-boat under a long-term materiel procurement programme have been announced. A total of 26 large patrol flying-boats would be produced for the Japanese naval air arm to replace the P2V-7s and S2F-1s at present used for coastguard and anti-submarine duties. The flying-boats would be supplemented by large helicopters in the coastguard role. Delivery of the 26 aircraft should be complete by 1970.

●

Thiokol-Reaction Motors Inc.'s XLR-99 throttling lox-ammonia rocket engine of 50,000 lb thrust has completed all the necessary preliminary static tests before being sent to Edwards AFB, California for installation in an X-15. A powered flight is possible during April or May if systems ground tests are satisfactory. A two-stage ignition chamber with a low-tension spark plug fires the engine at any altitude. As many as 11,000 restarts, some of them in a vacuum, have been made with a test engine. These include firings at a simulated altitude of 100,000 ft in a new test facility at Tullahoma, Tennessee.

●

Rolls-Royce has released first details of the RB.163 by-pass engine for installation on the Airco DH.121 and the Vickers VC.11. The engine has a by-pass ratio of 1.0, and maximum continuous thrust is 9,850 lb for a specific fuel consumption of 0.578 lb/lb/h. The comparable figures for maximum continuous cruise are 9,450 lb thrust and 0.570 lb/lb/h consumption. Mass flow is 202 lb/sec; maximum basic dry weight is 2,315 lb. The compressor has a two-spool layout, apparently with four low-pressure and twelve high-pressure stages. The turbine unit has four stages and is followed by a mixer. Thrust reverser and silencer are apparently standard components. The RB.163 is scheduled to run for the first time in November, 1960; the first flight tests will start in November, 1961.

●

An aluminized plastic balloon with a diameter of 100 ft has been fired to a height of 250 miles from Wallops Island, Va., test range. The balloon successfully relayed a twelve-word message transmitted by Bell Telephone Laboratories, Holmdel, N.J., which was clearly received at several points, including the Massachusetts Institute of Technology's Round Hill station.

●

The General Electric T58-8 turbine engine has passed its official military 50-hour preliminary flight rating tests. The 58-8 is basically a higher-powered version of the T58-6, which is in production and flying in military and civil helicopters. The increase in power was achieved mainly by raising turbine temperatures, the powerplant's basic configuration remaining unchanged. It is possible to convert the -6 to the -8 model at overhaul.

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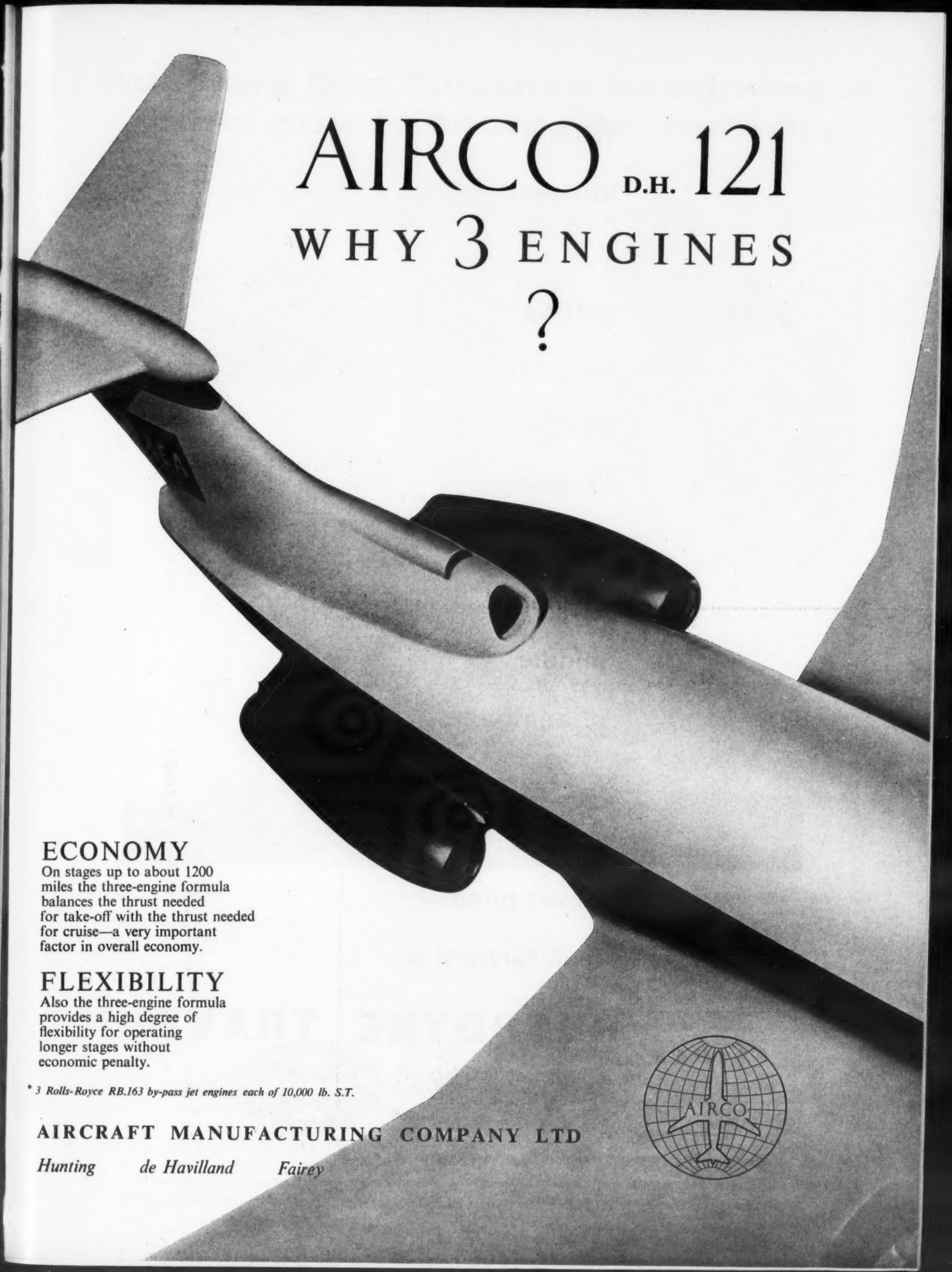
ハイパー
三国志



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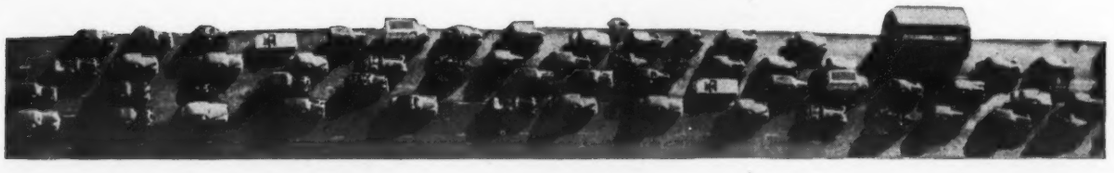

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Helmut Schelp, chief engineer, AiResearch Manufacturing Division of Arizona, Phoenix, surrounded by typical gas turbines now in production ranging in size from 30 to 850 hp. Clockwise from the top : GTC 85-28 GTCP 105 • GTP 70-6 • GTP 30-1 • GTP 70-10 • GTU 85-2.

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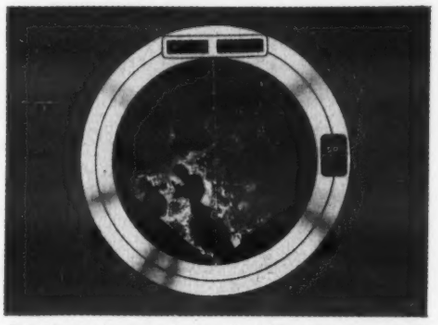
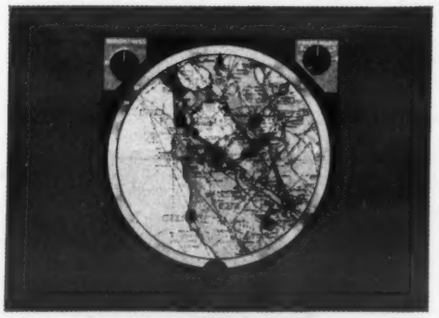


The display above furnishes radar information as a navigational check against the moving map display (below). It makes direct navigation to target possible in any weather.



The Moving Map Display provides the pilot with continuous position and course information. At each designated check point during the mission, the system automatically checks the map position against the radar display and makes the necessary flight corrections.

For further information please write to Hughes International, a Division of Hughes Aircraft Company, Culver City, California, U.S.A.

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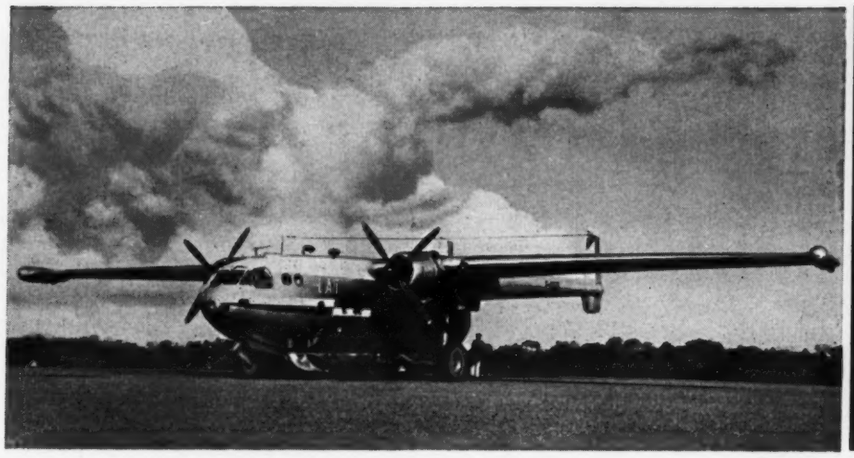

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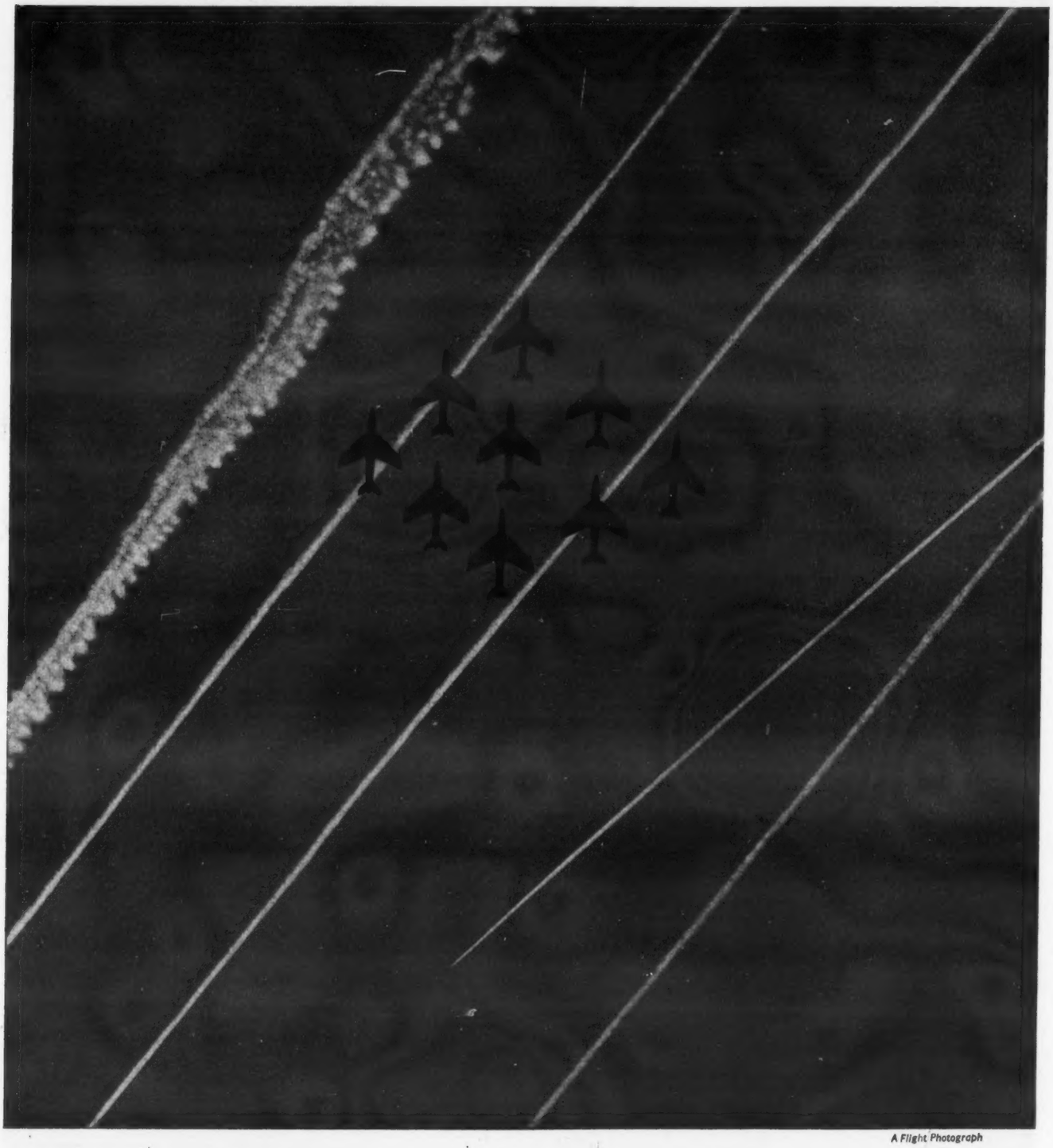


A Flight Photograph

Government and Aircraft Industry are Partners

BY SCOTT HERSHEY, NEW YORK

A series of strong recommendations of great significance to the aircraft and air transport industries has come from the Aviation Securities Committee of the Investment Bankers Association of America.

These recommendations, if followed, could have far-reaching effects on the industry generally, particularly as they originated with experts in the field of aviation securities in the investment banking business.

The Committee stated that "the critical danger threatening our national objectives in light of Soviet space probes, military power and Communist economic penetration demands the full understanding and support of the vital partnership which exists between the U.S. Government and the aviation industry."

In the going controversy over the "missile gap," or lack of it, between the United States and the Soviet Union, a subject much will be heard about in the election campaign months to come, these recommendations have not had the attention they deserve.

In making the recommendations, the Committee said that since the Government and the aviation industry form a partnership, the partners must recognize that each is entitled to equitable treatment and that neither can have it all his own way.

With this in mind, the Committee "strongly" recommended :

1. That MATS (Military Air Transport Service) be limited to a hard-core military mission, but in this connection it should be given the most modern aircraft for that purpose, including equipment which could immediately support any strike by the Strategic Air Command.*

2. That the airlines take over the major part of the MATS cargo and personnel transport commitment, in order to develop the potential of the air cargo business to the point where costs to the Government and to the public could be considerably lowered.

3. That the Government recognize the great need for development of an expanded cargo airlift for commercial and military purposes and should therefore give assurance of some form of assistance in developing new cargo aircraft which will permit the most efficient operations. Additionally, this would help the commercial carriers to build up a large modern fleet which would be available to the military through the Civil Air Reserve Fleet.

In connection with the above, the majority of the Committee do not feel that guaranteed loans would necessarily be of major importance to the development of the air cargo business. One member of the Committee feels that a guaranteed loan program would be unsound and unneeded and that its implementation therefore would be contrary to the free enterprise philosophy—its effect would be to increase the debt burden of the companies least able to support more debt.

4. That the Administration appoint an individual of outstanding ability to study the problems of air transport industry regulation in the jet age and seek to develop a new program which the Administration could support and submit to Congress for required legislative action.

The Committee suggested that meanwhile " the CAB show more amenity to the aims and needs of the airlines and act accordingly with all the vigor that the Board, with its new members, should develop—and stick to the philosophy and principles of the Civil Aeronautics Act."

5. That the Administration and the Congress use their influence and, if necessary, their powers, to bring the views and perspectives of these aviation partners into focus and into a practical, effective and constructive relationship.

The Committee holds that, together, Government and industry provide for free world defense. Together they strive to capture space leadership. They seek progress in trade, commerce and travel through advances in air transportation.

While the Committee feels that in recent months jet and space age activity gave some testimony to the worth of this relationship, it noted that in the same period there also was a measure of strain and imbalance between industry and Government that was not in the national interest.

"We focus attention on this partnership," the Committee said, "and conclude that, therein, the capacity exists to meet the major challenges of our era. It is clear, however, that changes in policies and actions by the admittedly-senior partner (Government) are vital to our continued well-being as a nation."

The aircraft industry has been and will continue to be heavily dependent on Government business. It constitutes for the Government an important defense and economic resource.

It is not incongruous, the Committee stated, that some form of Government assistance is proper to buttress and accelerate the boom that most predict—for the air freight industry for example.

If the need for Government backing is demonstrated, it fits definitely into the national policy to develop a sound air transport system for defense and for commercial needs.

The Committee noted that since competition in the upcoming air cargo transport field includes not only U.S. manufacturers, but also aircraft designed and built abroad, the foreign aspects cannot be divorced in this case from the domestic. Today, the British, French and Canadians are offering aircraft terms and credits which U.S. manufacturers say they cannot match. Tomorrow the Russians may be added to the list.

Also, there have been suggestions that now is the time for the Government to consider the impact on U.S. defense industries should disarmament or arms control come about.

"An obvious way to soften the financial and employment impact would be for our Government to assist by all proper means the sale here and abroad, of modern transport and cargo airlift," the Committee said.

The alternative to Government pump-priming, the Committee said, is to let things drift along into a big competitive battle two or three years hence, while foreign manufacturers absorb the immediate domestic market.

The Committee suggested that "attitudes of indifference, almost opposition to the aviation industry by the CAB should, indeed, be a thing of the past and should have no place in the new picture. For in the years ahead, the transport airplane will wield too powerful an influence in world military and commercial affairs."

In regard to the National Aeronautics and Space Administration, the Committee said most people familiar with our space research seem to agree that NASA has done well in organizing a sound program despite the limited support given it by Congress.

But they also see "frightening evidence" that the Government is not taking needed action to accelerate the snail's pace in this field. This might be traced, the Committee said, to lack of leadership in setting firm national goals to achieve superiority in space research in light of Soviet progress.

Overall, the Committee said, it appears that the first step is for the United States to make up its mind whether or not to engage in a space race with the Soviet Union. But first, the White House must agree; second, Congress needs to be convinced; and third, an often-confused public deserves better than a diet of conflicting reappraisals and policy shuffling by their Government leaders.

It appears that one way to end "lip service" to our space race with Russia is to exploit the advantages of the Government's partnership with industry, the Committee said, by getting qualified men from the aviation-missiles-electronics fields—men marked with prestige and success—and permit them to give the country the benefit of their experience.

Walter M. Giblin, of Blyth & Co., Inc. is Chairman of the Aviation Securities Committee of the Investment Bankers Association of America. Members are: Sylvan C. Coleman, E. F. Hutton & Company; Richard W. Courts, Courts & Co.; S. T. Mason Frey, Bankers Trust Company; William B. Harding, Smith, Barney & Co.; Herman H. Kahn, Lehman Brothers; Donald N. McDonnell, Blyth & Co., Inc.; James P. Mitchell, The Chase Manhattan Bank; and John Raiss, Burnham & Company.

* Meanwhile, President Eisenhower has in fact approved a Defense Department proposal to hand over a major portion of MATS' business to the airlines, and Air Force Secretary Dudley C. Sharp has been directed to complete a programme for carrying out the recommendations by May 1st, 1960.

INTERNATIONAL MEETINGS AND CONFERENCES

Mar. 8th-11th: ATA Agency Committee Meeting. Washington, D.C.

Mar. 9th-10th: Symposium on Processing Materials for Re-Entry Structures, sponsored by Midwest Chapter of the Society of Aircraft Material and Process Engineers. Dayton, Ohio.

Mar. 9th-11th: Conference on Mechanical Properties of Engineering Ceramics, sponsored by Office of Ordnance Research and North Carolina State College. Raleigh, N.C.

Mar. 9th-11th: ISA Temperature Measurement Symposium. Columbus, Ohio.

Mar. 10th-11th: Institute of the Aeronautical Sciences, Flight Propulsion Meeting (classified). Cleveland, Ohio.

Mar. 11th: Royal Aeronautical Society, Symposium on Vehicle and Instrumentation Problems in Upper Atmosphere Research. London.

Mar. 14th-18th: National Association of Corrosion Engineers, 16th Annual Meeting. Dallas, Tex.

Mar. 15th: Electronic Industries Association, Defense Planning Seminar. Washington, D.C.

Mar. 17th-29th: ICAO, 5th North Atlantic Ocean Stations Conference. The Hague.

Mar. 21st-April 9th: ICAO, Two Sub-Committees of the Legal Committee on (i) the Tokyo Draft Convention and (ii) the Draft Convention on Aerial Collisions. Paris.

Mar. 21st-24th: IRE International Convention. New York.

Mar. 22nd: IATA Radio Systems Group. Montreal.

Mar. 22nd-24th: 20th High-Polymer Physics Meeting. Detroit, Mich.

Mar. 22nd-29th: International Federation of Air Line Pilots' Associations, 15th Conference. Istanbul.

Mar. 23rd-25th: American Rocket Society, Ground Support Equipment Conference. Detroit, Mich.

Mar. 23rd-25th: Symposium on Optical Spectrometric Measurement of High Temperatures, sponsored by University of Chicago Applied Science Laboratories, Jarrell-Ash Co. and National Science Foundation. Chicago, Ill.

Mar. 24th-26th: National Aviation Education Council, 4th National Conference on Aviation Education. Denver, Colorado.

Mar. 29th-31st: ASME 22nd Annual American Power Conference. Chicago, Ill.

Apr. 3rd-8th: Sixth Nuclear Congress. New York.

Apr. 4th-8th: AGARD Combustion and Propulsion Panel, High Mach Number Air-Breathing Engines. Milan.

Apr. 5th: IATA European Traffic Handling Committee, 6th Meeting. Paris.

Apr. 5th-8th: Society of Automotive Engineers, National Aeronautic Meeting. New York.

Apr. 6th-8th: Institute of Environmental Sciences National Meeting. "Hyper-Environments—Space Frontier." Los Angeles, Calif.

Apr. 6th-8th: Structural Design of Space Vehicles Conference. Santa Barbara, Calif.

Apr. 8th-9th: Society of the Plastics Industry, 17th Western Section Conference. Palm Springs, Calif.

Apr. 12th-27th: Milan Trade Fair. Milan.

Apr. 14th-24th: International Air and Space Exposition. Los Angeles, Calif.

Apr. 19th: IATA Legal Committee, 25th Meeting. Virginia Beach, Va.

The British White Paper on Defence

Even in that section of the British press which is least critical of the authorities the tone of the leading articles takes on a certain asperity when mention is made of the British White Paper on Defence for 1960 and the Defence Budget for 1960/61. This is, perhaps, hardly surprising, for the funds allocated for defence have risen to £1,629 million, compared with £1,514 million in the previous year—despite the fact that the 1957 White Paper had promised a continued decrease in armament costs. "The taxpayer has a right to know why the Government want an extra £115 million from him," declares the *Times*. And the *Financial Times* complains: "With defence costs once again climbing it may seem too late to urge that Britain should not endeavour to reduplicate American defence research."

These remarks show that things are once again back to normal. Whereas the White Papers and Budgets of the last few years spoke of revolutionary innovations in the field of guided missiles, and public comment centred almost exclusively on technical and strategic problems, the talk is now first and foremost of pounds, shillings and pence.

Although the new White Paper declares that *British defence policy has undergone no major change*, this is only true in a limited sense. For, in this first comprehensive report since taking up office, Defence Minister Harold Watkinson has laid down guiding lines for British armament policy which, though not entirely new, have not been followed through so consequentially in any White Paper so far presented:

Mobility, flexibility, automation, shift in emphasis from the soldier to the technician.

Heightened mobility will initially take the form of an increase in the means of rapid troop transport, "so that reinforcements can be brought to trouble spots before the trouble has time to spread into a major conflict." Deliveries of the Bristol *Britannia*, which began in 1959, are to continue, and the RAF's strategic transport force will also receive deliveries of the Short *Britannic*. The tactical transport force will be reinforced by Armstrong Whitworth A.W.660s (military version of the *Argosy*), Westland *Whirlwinds* and other helicopters of more modern design. Development of the Fairey *Rotodyne* is to continue.

But the concept of mobility is also extended to deterrent weapons, and here the fate of the de Havilland *Blue Streak* strategic surface-to-surface missile (range 3,000 miles) is cast into the balance. The White Paper does, it is true, announce that development of the missile will continue, but adds the following reserve: "However, it may be decided not to rely exclusively on fixed-site missiles as the successor to the medium bomber armed with the stand-off powered bomb. Therefore the possibilities of mobile launchers, whether aircraft or submarines, for long-range delivery of nuclear warheads are being investigated."

It is understandable that the Navy, headed by Lord Louis Mountbatten, has accepted this idea enthusiastically and is pressing for the immediate cancellation of *Blue Streak*, which is vulnerable to surprise attack; the naval man's ideal is the nuclear-powered submarine armed with guided missiles in the style of the American *Polaris*.

The *Times*, on the other hand, complains that the Government has arrived at its consideration somewhat tardily: "... it is too late to stop the *Blue Streak* project because it would be almost as expensive to cancel as to complete it."

The Royal Air Force has raised the objection that the construction of nuclear-powered submarines would require an enormous amount of time and money. Moreover, says the RAF, *Blue Streak* constitutes the sole British deterrent weapon which would be operational in the near future, and to abandon it would at the same time mean the loss of the only British booster and hence the end of space research as far as Britain was concerned.

As for *flexibility*, the "missilitis" from which British defence planners seem to have been suffering since the 1957 White Paper has given way to the concept of a "balanced force," which would have at its disposal both guided missiles and an adequate number of manned aircraft. "The V-bomber force," says the White Paper, "remains the United Kingdom's main contribution to the strategic nuclear power of the West." The English Electric P.1B *Lightning* will go into service within the next few months, and development of the TSR.2 strike and reconnaissance aircraft is progressing satisfactorily.

The Navy, too, has been allotted its fair share of manned aircraft. The Vickers-Supermarine *Scimitar* single-seat day fighter/strike aircraft and the de Havilland *Sea Vixen* two-seat all-weather fighter armed with *Firestreak* air-to-air missiles are now operational, and Blackburn has received a contract to build the NA.39 strike aircraft.

The *shift in emphasis from the soldier to the technician* is well on the way. By 1962, service manpower will have been reduced to 400,000 from 700,000 in 1957. About 25 percent of the total annual officer cadet entry is, however, receiving technical training, and in the last five years the proportion of highly skilled tradesmen in the total strength of the Army and the RAF has risen by 50 per cent.

These, then, are the major new points in the British White Paper on Defence for 1960; the British and U.S. defence budgets will be dealt with in more detail in a later issue of *Interavia* Review.

XVIII

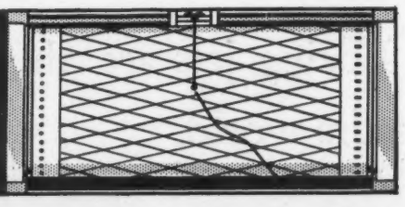
working pilot

The IFALPA delegate speaking to the ICAO Special Meeting, Montreal, February 1959

I should like to describe what we have been able to do using Radar for departures. Four aircraft taxi out at the same time. They are fully loaded, it is a hot night so they have an immediate problem. After take-off Departure Control wants immediate contact so we give them a call. Number 2 aircraft takes off two minutes later, and receives the same clearance until he picks up Radar Departure, who say " Turn left heading 050° "— now this is into inbound traffic, which means he will require continuous attention from Control to make sure he picks his way safely through the incoming traffic. Aircraft number 3, two minutes later, same as before, except when he picks up Radar Control, the Controller says " hold 4,000 ft. heading 130°," (he has vectored him off so as to clear the way for aircraft number 4). Aircraft number 4 receives the same departure, but he is told to hold 3,000 ft., and the Radar Controller's attention will also be especially directed towards him because he is bucking the flow of traffic in a place where he does not properly belong.

With regard to the overall achievement, we have now vectored four aircraft into a single airway. Only one of them has achieved the altitude he wanted, and unfortunately he will have to come down through the altitude of the others. Radar is a marvellous device, and it has solved many of our problems, but it is *not* a navigational aid. An area coverage system would not solve every problem, but it would provide the capability of outbound tracks that would take us immediately out of the area from whence discrete tracks could be drawn giving lateral separation of a safe order. This is a problem which is incidental to the use of single track airways, and we feel **it can be solved by lateral separation which should be made available through pictorial presentation coupled with area coverage.**

THE DECCA NAVIGATOR



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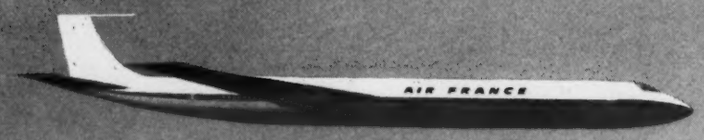

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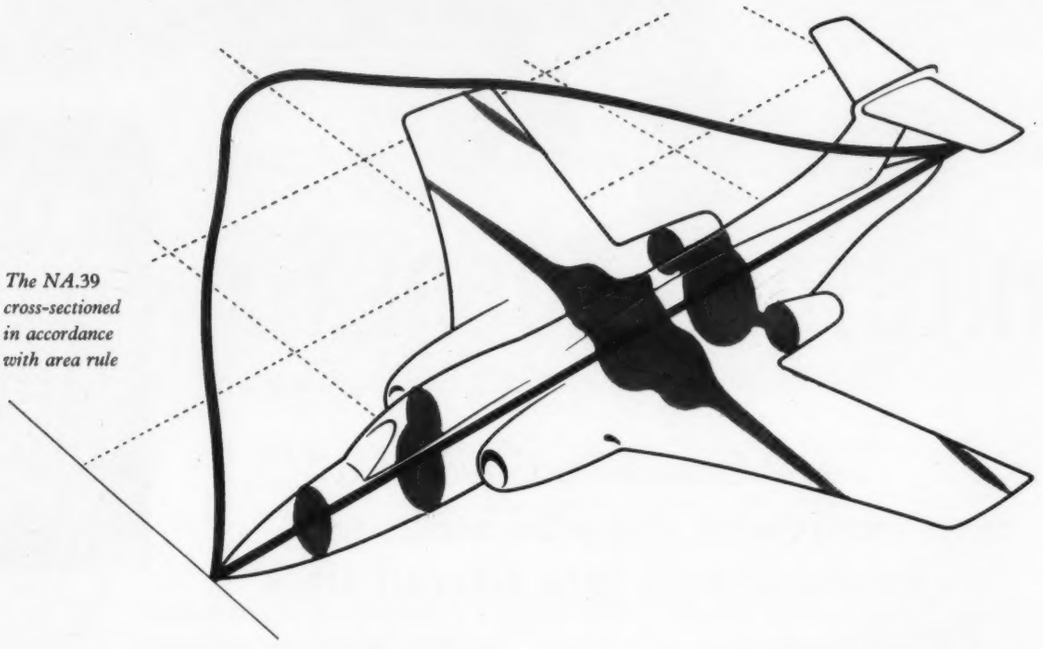
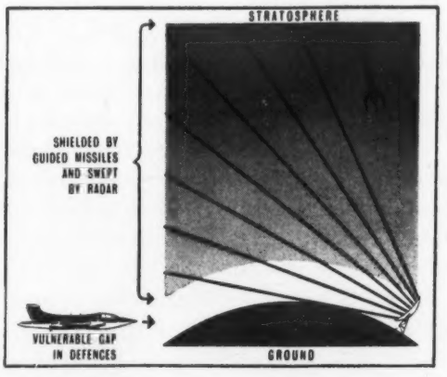
"The NA.39 is ahead" *



The NA.39 cross-sectioned in accordance with area rule

Area rule minimises drag because it allows the airflow *gradually* to contract and expand over the *total* cross-section of the aircraft. This has special virtues for high-speed, low-level flying because it ensures good control response and a smoother ride for the crew.



* *"In the low-level strike role, the NA.39 is ahead of any other aircraft in the world."*
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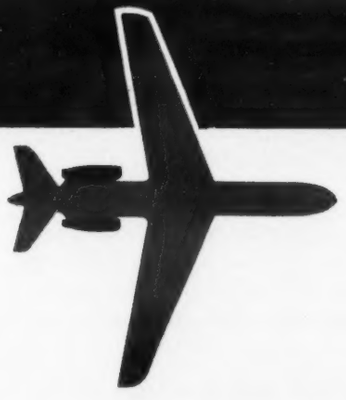

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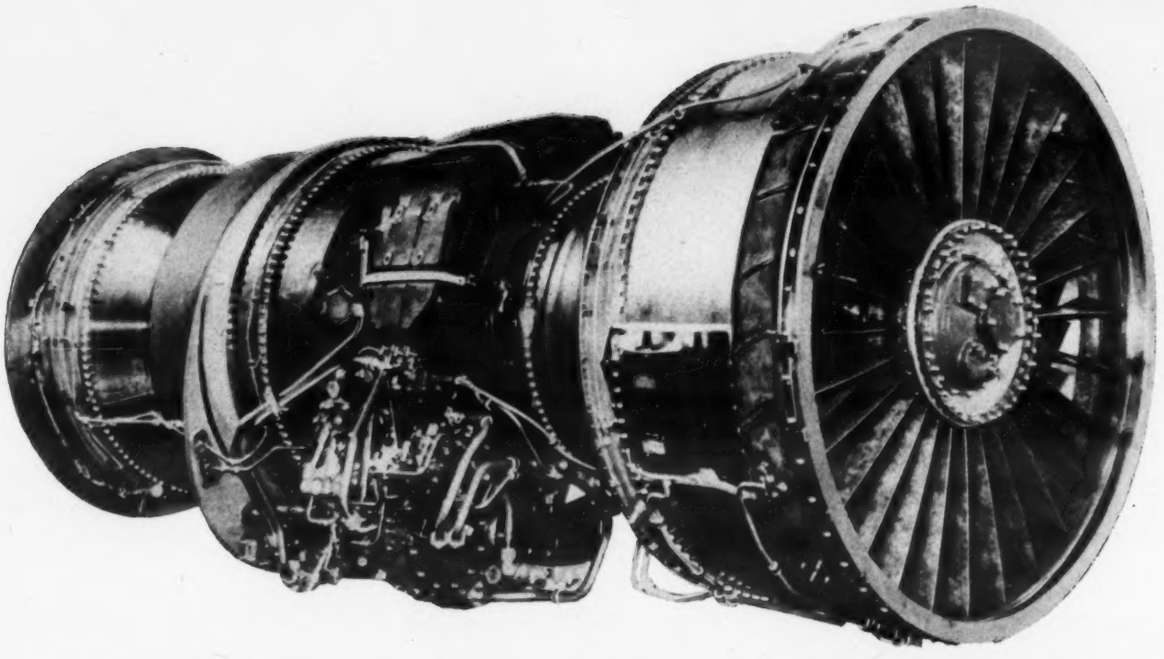

PRATT & WHITNEY AIRCRAFT'S NEW JT3D TURBOFAN ENGINE INHERITS THE EXTRAORDINARY RELIABILITY OF ITS PREDECESSOR, THE J-57 TURBOJET, PROVEN IN 6 MILLION HOURS OF FLIGHT. AT THE SAME TIME, IT SETS A NEW HIGH IN THRUST AND A NEW LOW IN FUEL CONSUMPTION.

The new JT3D turbofan has the same basic design as the JT3 (J-57) and JT4 (J-75) turbojets powering 9 out of 10 Boeing 707 and Douglas DC-8 jetliners and many military jet aircraft. Functionally, the difference is the addition of the fan and provision for a secondary flow of air. The reliability has not changed because the basic engine design has not changed. But the addition of the fan has effectively increased the thrust and decreased fuel consumption for greater operating efficiency. It is simply a case of the most reliable jet engine in its class getting even better.

By comparison with its predecessor, Pratt & Whitney Aircraft's new JT3D turbofan raises take-off thrust by 42%, boosts climb thrust by 23%, and pushes maximum cruise thrust up 13%—all this while cutting down cruise TSFC by 13%.

The JT3D, flying since July, 1959, has met or exceeded all performance guarantees and estimates and has successfully completed its 50-hour military test. Military prototype deliveries have been made. Military production deliveries start in June, commercial in July.

Pratt & Whitney Aircraft engines are serviced by a world-wide network of parts and maintenance representatives.

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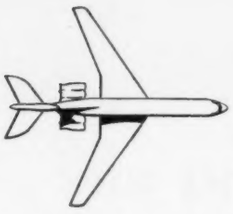
THE SHAPE  OF THE FUTURE

The wing is free to do its job...

because the engines are in the right place

The airline silhouette of the future, with its clean wing and rear mounted engines, offers many important advantages:

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- Full span leading edge lift devices and uninterrupted flaps
- Much reduced fire risks with no tanks or fuel lines in turbine disc areas
- Better performance margins and unique payload/range capabilities
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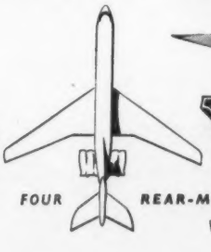
- No handling problems in critical engine-out situations
- High-set engines with minimum debris risk
- Simpler maintenance from better systems access
- Reduced engine mounting structural difficulties

For the above, and for many other reasons, rear-mounted engines represent one of the greatest advantages in aircraft layout.



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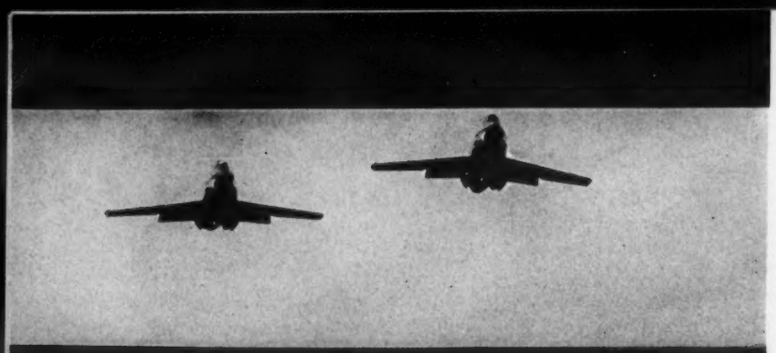

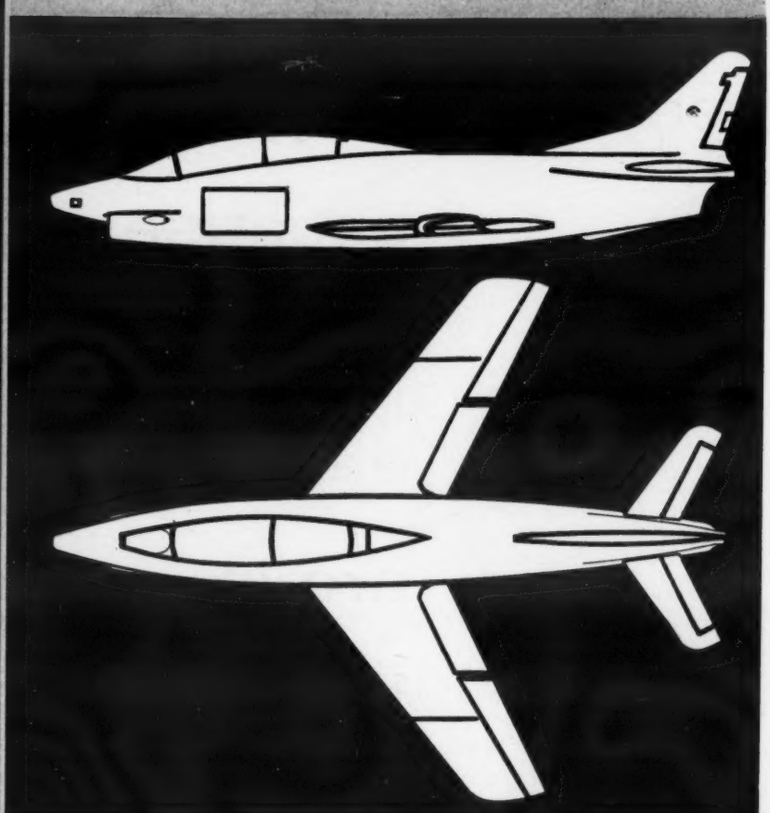

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FIAT G 91 T **Bristol Siddeley Orpheus 80 302**

The jet trainer, with characteristics and performance similar to those of the lightweight strike fighter version, is an aircraft especially developed for advanced training up to supersonic speeds. Meets all the requirements of the latest NATO standard and ABC agreements.

FIAT G 91
Bristol Siddeley Orpheus 80 302

The lightweight strike fighter, winner of the NATO contest. Basic advantages :

— small in size, light in weight, easy and comfortable to fly, ability to operate from a small space on semi-prepared strips or grass runways.

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FIAT G 91 R **Bristol Siddeley Orpheus 80 302**

Photographic version of the lightweight strike fighter. It is capable of performing day missions at high speed and low altitude, taking photographs forwards, backwards and to right and left simultaneously, or vertical photographs.

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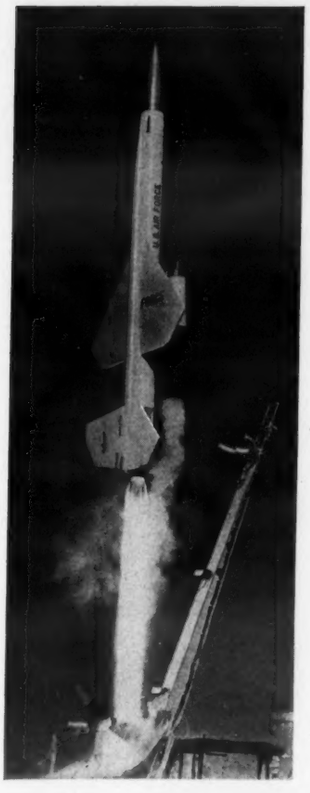

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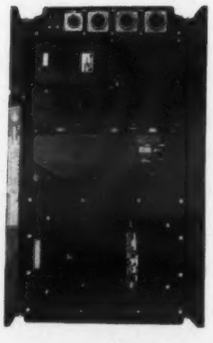

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THE LEADING AIRLINE FOR SERVICE

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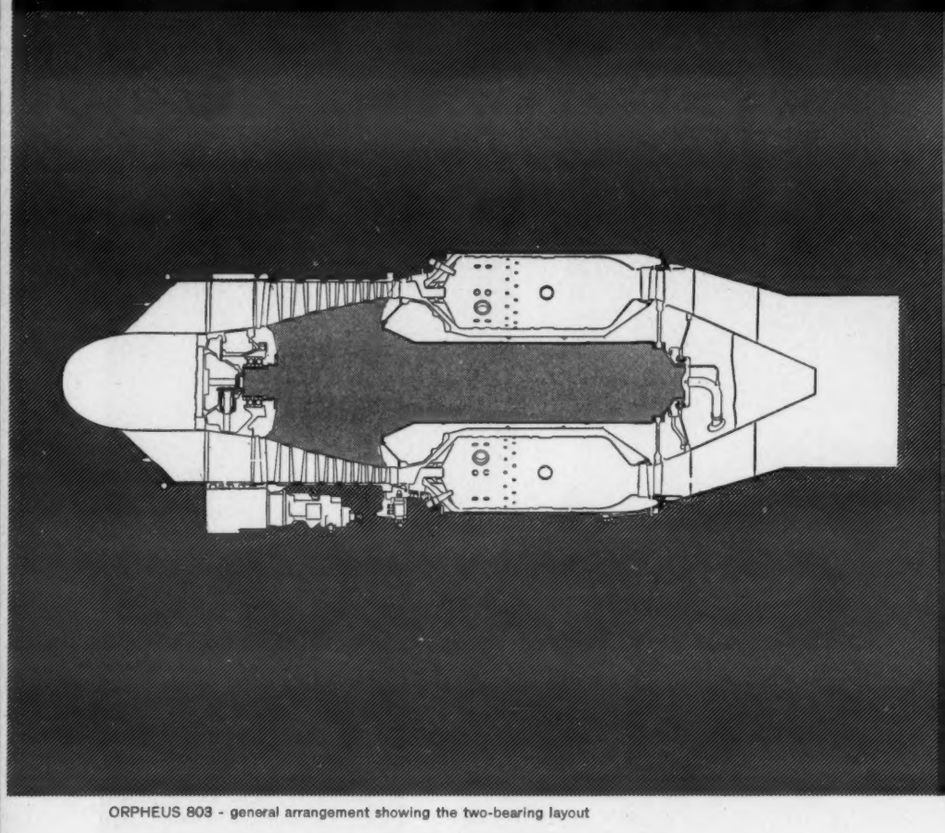
Orpheus turbojet—already flying in 6 different aircraft—now reaches 6,810-lb thrust dry, over 6:1 thrust/weight ratio...



ORPHEUS 803 - general arrangement showing the two-bearing layout

...ANOTHER ENGINEERING ADVANCE BY BRISTOL SIDDELEY

The design philosophy behind the Orpheus family of engines was based on two conflicting requirements—extremely light weight and exceptional reliability. That these requirements were successfully reconciled is shown by the fact that the Orpheus has been specified in five countries for no fewer than 14 distinct types of aircraft, six of which are already flying. The Orpheus is undoubtedly the most advanced medium-thrust turbojet engine in the world and the latest version, the B Or 12, has more than twice the thrust of the original Orpheus which first flew in 1955.

The Bristol Siddeley Orpheus B Or 12, like the earlier versions, achieves its outstanding performance through basic simplicity of design. Producing 6,810-lb thrust dry (8,170-lb thrust with simplified reheat), for a weight of 1,100 lb, the B Or 12 has a very high thrust/weight ratio of over 6:1. This is combined with a good specific fuel consumption (0.933 lb/lb/hr at maximum continuous rpm, sea-level static conditions), very compact dimensions (81.4 in from intake flange to exhaust flange; 32.4 in diameter), and minimum servicing requirements.

Omnipresent Orpheus

The Orpheus family has a far wider range of applications than any other aero-engine in its class. The design has been proved by a remarkable record of trouble-free operation and various Orpheus versions power aircraft ranging from trainers and executive transports to research aircraft and lightweight strike fighters. The last category includes the Fiat G 91, NATO's standard strike fighter, powered by the Orpheus 803 (shown above).

The Orpheus is in production in India and Italy as well as Great Britain, and will shortly be built in Germany.

BRISTOL SIDDELEY ENGINES LIMITED

The First Three Months: A Promising Start

Two main aspects of world aviation, whose achievements and problems it is *Interavia's* aim to report, claim attention in this first quarter of 1960. In the field of commercial aviation, data for the first year's scheduled jet operations have been released. On the military side, there has likewise been an important development, namely the conversion of interceptors to offensive aircraft, resulting in the sudden opening of a vast and unsuspected market throughout the world. *Interavia* has devoted a number of pages to both these aspects of aviation and invited the opinions of experts from various countries.

First, where commercial aviation is concerned, the results for 1959 are by now more or less well known. They are of particular significance in view of the steady increase in the numbers of jet aircraft placed in scheduled service during the period. In the United States, the country of air travel *par excellence*, the increase in traffic has been striking; the public has taken jet travel to its heart. Continental Airlines, for instance, whose load factor was falling in spite of the use of turboprop airliners, found that passenger load factor could be raised by 30 percent simply by introducing the four-jet Boeing 707-120. The passenger-miles performed during 1959 by American Airlines were 15 percent above those for 1958. Trans World Airlines also announces a considerable increase in the number of its passengers. By and large, the statistics show that American operators carried some 5 million passengers more than in the previous year on their domestic and international networks, an increase of over 10 percent. It is true that, as a result of the 1957 recession, 1958 was not among the best years. But the increase is remarkable nevertheless. Forecasts for the coming months, too, are eminently favourable, for they promise a turnover considerably in excess of that for 1959.

This optimism as regards traffic is, however, held in check by the prospect of the profits which it will yield. The 1959 figures were established on the basis of nearly 230 turboprop and some 85 jet aircraft at present in service in the United States. By the end of this year the number of turboprop aircraft will have risen to 267 and the number of jets to as much as 240. The airlines will thus have doubled the seat capacity available today. The average load factor will drop, and with it profits. As early as last November the average load factors of U.S. domestic operators had reached an all-time low. In Canada, too, Trans-Canada Airlines had to admit that, despite the fact that it had for the first time carried three million passengers, load factor had dropped from 70 to 66 percent. Stock exchanges are well aware of these two sides to the air transport picture—the increase in traffic and the possible reduction of profits—and are fighting shy of buying shares.

But, say the experts, what counts is that the public is being attracted to air transport in ever-increasing numbers. In his report for 1959, Max Hymans, President of Air France, said that his company's *Caravelles* were 88 percent full on the London–Nice service and 99 percent full on the Paris–London route. In Europe, too, jet propulsion has clearly met with travellers' approval. Constant technical improvements will make it possible to reduce fares and thus attract enough passengers to raise the load factor.

There is no doubt at all that, financially speaking, jet operations are marginal. Hardly had American Airlines placed its Boeing 707-120s in service than the constructors were studying a new version, powered by General Electric CJ-805-21 turbofan engines. With 10 percent lower fuel consumption and higher payload capacity, this version of the 707 will cost less to run, carry more and enable fares to be reduced and the number of passengers to be increased. The coming year, and in a still more marked degree 1961 and 1962, will beyond all doubt see the triumph of the turbofan and by-pass engines, paralleled by a further reduction in air fares and a new sector of the community won over to air travel.

*

On the military side there has been unexpected enthusiasm for the tactical aircraft. Although the missile has won pride of place in the great Powers' arsenals, the aircraft is now undoubtedly making a come-back. In the USA, Republic has announced that the USAF may order about a thousand F-105s over the next few years. Japan is ordering 200 F-104s and, in Europe, Federal Germany estimates that she will require 630 of these aircraft, the Netherlands 150 to 200, Belgium 100 to 150, and the RCAF in Europe 200. Thus, some twelve to thirteen hundred aircraft have been ordered in less than a year. And it must be borne in mind that this is no simple aircraft, but a weapon system of revolutionary design, fitted with complex electronic equipment and designed to perform a variety of tasks.

For the aircraft industry in Europe "Operation *Starfighter*" is of vital importance. The German industry—until recently virtually non-existent—will take a lead in the production of about a thousand high-performance aircraft. The most advanced American electronic techniques have been introduced into Europe, and Philips, for one, expects to get a substantial share of the electronic production. Finally, one of the most highly-developed American jets may be produced in Europe, benefiting industry in various countries. What is more, other States are expected to follow the lead of those mentioned above and purchase the Lockheed F-104 with American financial aid. These will be the Mediterranean countries and also, no doubt, Denmark and Norway.

But whether the aircraft in question be Lockheed F-104s, Republic F-105s, *Mirage III* strike fighters or *Drakens*, they all have one thing in common: they are first and foremost offensive aircraft and, as such, are equipped with a formidable battery of electronic equipment whose value is greater than that of the airframe. The equipment is designed to fit them for strike missions in all weathers, navigation at any altitude, LABS bombing, blind attack with air-to-surface missiles and rockets etc. In the following pages the editors of *Interavia* have tried to give an idea of the techniques by which engineers have managed to impart to a single-seater the characteristics of an aircraft which would formerly have required a crew of at least three men, and which could never have carried out a third of the missions which general staffs demand of fighter-bombers today.

Over 2,000 single-seat fighters on the West's order-books, the growing importance of electronics, a striking increase in air traffic: such are the characteristics of the last few months' activities. Manufacturers and technicians in the world's aircraft industries should indeed have cause for satisfaction.

***

Fifteen Months of Jet Operations

New Transports in the New World

Looking back at the American air transport scene in 1959, it would be difficult to select an arbitrary date in the early part of the year and say "That marks the beginning of the Jet Age." There are many factors to be considered in the selection of such a date, and it is simpler to report that the beginning of 1959 saw the entry of civil jet aircraft into passenger service in steadily increasing numbers. A year has elapsed since those first eagerly awaited inaugural services, and it is now time to record the first birthday of the "Jet Age." In saying "Happy Birthday" to the year-old infant, it is the obvious moment to inquire whether its progress has been satisfactory, and whether it is living up to all the forecasts that were made for its future.

During the past year, the phrase "Jet Age" was perhaps the most used term in the world of aviation. Representatives of all branches of the industry, from aircraft manufacturers to airline operators and travel agents, referred to it constantly and publicised the advantages it was to bring.

The optimistic expectations are now a thing of the past; the jet aircraft has firmly established itself on the United States air routes, and it is possible to take an objective look at the situation as it exists today.

*

Obvious starting point for such a review is with the aircraft manufacturers themselves. Of the three American constructors who are engaged in production of large civil jet aircraft, the *Boeing Airplane Company* has been the most prominent to date. This prominence has been a function of aircraft availability, as during 1959 a total of 81 Boeing 707s (including variants) were delivered to the airlines and brought into service. This figure includes 12 aircraft delivered to non-U.S. carriers and which do not come strictly within the scope of this review, but it is of particular interest as a measure of the rapidly changing equipment in the world's major airlines. By the end of 1959 the 100th jet airliner to be produced by the constructor was rolled off the production line in readiness for flight testing and delivery, and at the same time the company was able to announce that the two millionth passenger had been carried in Boeing 707s, and that during the year the airlines had flown more than 44 million miles in some 112,000 flight hours.

The two remaining manufacturers, *Douglas Aircraft Co., Inc.* and *Convair Division of General Dynamics Corp.*, have not been able to participate to the same extent in this initial development and expansion. Owing to differing time scales the delivery programmes for both these manufacturers extend farther ahead than that of Boeing. In the case of the Douglas DC-8 only 18 deliveries were scheduled up to the end of 1959 while the bulk of DC-8 production will commence to flow in 1960. A similar situation exists with the Convair 880. Deliveries of this aircraft are scheduled through 1960 and 1961, while the larger Convair 600 will make its appearance in 1961 and onwards.

Journey's end. Pan American Clipper "Mayflower" disembarks passengers at Idlewild.

A young traveller aboard an Eastern Airlines DC-8. The view shows the cabin interior looking through the first-class compartment to the forward lounge.

Space to relax. The lounge area of a DC-8 operated by Eastern Airlines on the newly started "Golden Falcon" service.

The Boeing 707 or its longer range variant, the 707 *Intercontinental,* has consequently been the aircraft which has virtually pioneered jet travel on American carriers' routes. Transatlantic 707 services actually started in late 1958, and United States transcontinental services began in January, 1959. As increasing numbers of aircraft were received by the airlines and brought into scheduled service, the coverage was steadily expanded, and by July 1959 a trans-Pacific service was inaugurated. By the autumn of the year, complete round-the-world flights became a reality, and for all practical purposes the Jet Age had arrived.

*

Turning from the manufacture and suppiy of jet transport aircraft, the next point of interest is the operator. *Pan American World Airways* can claim to be the first U.S. carrier to introduce jets into service. On October 26th, 1958 this carrier commenced jet operations on trans-Atlantic routes and steadily increased the frequencies as further aircraft were received. During the peak period of the 1959 travel season, from June to September, 55 percent of the seats offered on the European routes were on jet aircraft. The effect of the introduction of the new transports was immediately apparent, and at the end of the year Pan American reported a 15 percent increase in passenger traffic. As less than half of the jet equipment on order for the carrier has gone into service as yet, this trend has prompted Willis G. Lipscomb, PanAm's Vice President-Traffic, to forecast a 20 to 25 percent increase in passenger traffic for 1960. Very similar figures have been reported by the two other carriers who were early starters in the jet age. *American Airlines* commenced transcontinental services on January 25th, 1959, while in March 1959 *Trans World Airlines* became the second United States airline to establish a transcontinental service.

These results, together with the high load factors reported in the early months of operation, leave no doubt as to the public acceptance and enthusiasm for jet travel. The reported figures have been higher than those for any previous transport aircraft on its inauguration into service. At the same time it must be remembered that the early results cover a period when the new aircraft were few in number and were being brought into scheduled service as they became available. It is obvious that the routes chosen for jet operations would be those which offered the best passenger potential, and the travelling public was also anxious to experience the novelty of jet travel. Standing so close to the event makes it difficult to assess the impact of the jets on 1959 travel volume. The industry showed a 13 percent increase in revenue passengers emplaned, but a proportion of this figure could possibly be attributed to the generally improved economic picture. Individual carriers' results did not exactly duplicate this general industry trend. In the case of American Airlines for example, a carrier with perhaps the most extensive jet schedules during the year, the figures for passengers carried showed only a four percent increase. At the same time, the passenger miles flown by American showed a fifteen percent upsurge—a figure in excess of the average for the industry, and an indication that the trend in travel was towards longer individual journeys. At the conclusion of the year's operations the carrier could at least quote these figures with enthusiasm, as the totals both represented new industry records.

Jet speed service. Coffee made at the touch of a button aboard Boeing 707 of American Airlines.

From the operators' standpoint, therefore, the first year's jet operations can be viewed with satisfaction, and the future with optimism. The public has accepted jets and the faster schedules they offer, and the indications point to a steadily expanding market. The pioneering is now over, and the opinions of the pessimists have been proved unfounded. There remains another part of the picture to be considered: the integration of jet operations into the general traffic pattern.

By the end of 1959 over 75 pure jet aircraft were brought into scheduled service on U.S. airlines. Thanks to adequate preplanning and preparation this has been achieved with the minimum of incident and mishap. During 1960 more than 150 jet aircraft will join those already in service, and a number of problems which are already apparent will become more acute. The integration of fast, high performance aircraft in a slower traffic control pattern presents a situation which has already caused airline operators to complain of expensive, time-wasting procedures necessitated by air traffic control conditions at busy airports. Much has been accomplished to improve this situation, but until even greater numbers of jets are in service and the new traffic patterns become more stabilized, it appears that modification to procedures will occur on an almost day to day basis. Only then will it be possible to assess what advantage the jet offers in journey time in comparison to present day schedules.

Other problems have arisen as a result of this "revolution in transportation." Considerable capital expenditure has been necessary to provide airports with runways of adequate length and strength, and the question of engine noise in relation to nearby residential localities has presented a number of social problems. The development of the "fan-type" engine may mitigate this situation but it will represent a further expense for the operating airlines to re-equip their fleets with new engines. Despite the operating economies promised for the "fan" engines, the savings in costs will not be of major assistance in amortizing the costs of the new equipment.

These "hidden" costs will be possibly the greatest burden the jet age will have to support for many years to come. The price of developing new and automated methods of air traffic control, of providing adequate ground and ground handling facilities, will to a large extent fall upon the operating companies who enjoy these facilities. At the present moment, despite record revenues, the economy of the air transport industry is delicately balanced, and heavier taxation to meet new costs will have far-reaching effects. The 1959 profit margin of 2.9% represents no change from the previous year and it also marks the third year in succession that the net profit after taxes has been below 3 cents on the sales dollar. The tendency towards greater taxation too is reflected in a recent proposal to make a levy of 4½ cents per gallon on jet fuels in the United States. On machines consuming 15,000 lb of fuel per hour, such a levy would entail a considerable increase in direct operating costs.

The U.S. airlines are committed to a $2,000 million bill for new aircraft, and at the same time are spending millions on training and general facilities; unless they are given sufficient freedom to increase their profit margins their prospects for future growth will be severely hampered and the advantages promised by the jet age will be stifled.

Opinions expressed by a number of airline executives all point to the same line of thinking for future operations. Results to date prove that the jet aircraft can produce a profit on high density routes with reasonable load factors. The danger may arise that some carriers for either competitive or prestige reasons may want to introduce jets on routes of marginal traffic potential. If this were to be the case the results could be ruinous in a comparatively brief space of time. Discounting this possibility, the future appears to be in the development of the low cost Economy fare structure. Given an economic atmosphere of this nature, then the traffic generated will be sufficient to fill the increasing number of seats which will be on offer in the coming year. As far back as 1943 Juan T. Trippe, President of Pan American, said "Air transport has the choice . . . the very clear choice . . . of becoming a luxury service to carry the well-to-do at high prices . . . or to carry the average man for what he can afford to pay." The choice still exists and it is apparent that airline managements are striving to attain a standard of low cost, efficient travel with every means possible.

The lack of agreement achieved at the 1959 IATA Conference in Honolulu points to a rather stormy future on the question of fare structures. Pan American have long been protagonists of the low-fare policy and quote their innovations in this field over a number of years, such as the first Atlantic tourist fare in 1952 and the transatlantic Economy fare in 1958. This carrier has stated its intention to press for further fare reductions at future meetings, with the eventual target being a world wide Economy fare. Such a proposal will not arouse a great deal of opposition from other U.S. carriers in principle. It is accepted that a steadily increasing number of seats have to be filled if the new aircraft are to pay their way. A period of uncontrolled competition can only result in a financial disaster which would be crippling to the air transport industry.

*

Turning from the profit-making capacity of the aircraft to the actual aircraft themselves, it is of interest to examine the process of their integration into the schedule structure. The operating airlines have been unanimous in their opinions of the new aeroplanes in terms of performance and reliability. The costs of introducing new types was high, but reductions in operating costs are expected as the traffic patterns become more stabilized. It is confidently anticipated that the jet aircraft can produce air transportation on a more economical basis than the DC-7. In terms of reliability the aircraft have maintained an excellent record and suffered from relatively few "teething troubles." Pan American's experience is noteworthy in this respect. This carrier quotes only one unscheduled engine change for every 2,700 hours operation, compared to one every 993 hours in DC-7s, and only one engine shutdown for every 11,000 hours, compared to one in every 1,315 hours for DC-7s. Despite this reliability both in engines and airframes there has been a greater incidence of schedule delays than was at first expected, owing to minor technical difficulties in engine and airframe accessories. As the incidence of these troubles has been varied in location it is not possible to point to any particular unit or units for investigation and redesign. The proof of satisfactory performance lies in the fact that the aircraft have entered into service and operated without a single serious mishap to a passenger-carrying aircraft. Owing to the news value of the big aircraft, a number of incidents have tended to be treated with greater publicity than was warranted. In one instance in particular the safety of an aircraft was gravely imperilled by the members of the public who flocked onto the runways of Idlewild Airport in

Crew training on a 707 simulator. The provision of training facilities has ranked high in the capital expenditure made necessary by the introduction of the new aircraft.

The 100th engine to be overhauled at American Airlines' Jet Maintenance and Engineering Center, Tulsa, Okla. Here the final checks are being carried out before release to Final Assembly.

A Boeing 707 of American Airlines undergoing routine maintenance. The photo emphasizes the accessibility of the pod mounted engines.

a Roman holiday mood, to watch the landing of a Boeing 707 with a damaged undercarriage. Such a situation would have passed unremarked with a conventional piston-engined aircraft, and only by piloting skill was a major disaster avoided. In several occurrences the gravity of the situation has been greatly exaggerated and does not reflect accurately on the performance reliability of the aircraft.

*

The last field for examination is that of air traffic control and the prospects for the integration of an increasing number of large high performance aircraft into the existing traffic patterns. It is here that the jet aircraft have encountered their greatest difficulties. Although many plans exist and development work is well under way for automated traffic control systems, the plain fact remains that today's jet fleets are operating under relatively the same methods of control as those employed ten years ago.

Apart from the insatiable appetite of the jet engine at low altitudes, which necessitates special high level holding procedures for aircraft awaiting landing instructions at busy airports, the problems of available airspace arises. Present day cruising speeds now dictate such wide geographical separation between aircraft travelling in the same direction that the airspace is becoming insufficient to accept the traffic. The introduction of greater radar coverage and surveillance will assist in relieving this problem, but at the same time the channels of Air Traffic Control are still clogged by manual methods of communication. Apart from the question of air safety the situation has a more far-reaching effect upon the introduction of further jet services. Complaints are beginning to arise from a number of operators that their proposed schedules are being vetoed because the workload of the Air Traffic Control agencies at the terminals and along the proposed routes will not accept the introduction of further traffic.

The new airport control tower at Newark, New Jersey. Built by the Port of New York Authority and operated by the Federal Aviation Agency, the tower is one of many new facilities which have been required to handle the growing problems of traffic control.

Within the United States this problem is well appreciated by the *Federal Aviation Agency*, and vigorous steps have been taken to clear the bottleneck. It is illustrative of the accelerated pace of the jet age that the aircraft are entering service and crowding the airways at a greater rate than jet age traffic control equipment and methods can be provided. The difficulties that have arisen during the first year of operations will not, however, remain as a permanent feature of future operations.

One other characteristic of the new transport age is worthy of comment. The increased capacity of these aircraft presents the operators with a problem distinct from that of selling sufficient tickets to fill all the seats. Loading over a hundred passengers together with their luggage on board the aircraft, to meet a certain take-off schedule, is a major administrative operation. Many new systems are under consideration to speed up this procedure. From the point of view of customer relations it is obviously unsatisfactory to advertise the ability to transport a passenger across the American continent in less than four hours, and then take over two hours to put him on and off the aircraft. Another problem is that of unscheduled stops due to weather or similar causes. The influx of over a hundred passengers at an alternative airport is one which will strain the resources of the local staff to breaking point. A moment's thought to the difficulties of finding accommodation or alternative travel for such a number of people will emphasize this point. The remedies are not easily found, but all the carriers are examining schemes to safeguard against these unforeseen occurrences.

It would appear that the year-old "Jet Age" is a healthy infant with a boundless future. The new transport has been enthusiastically accepted by the public, the carriers have indicated their intentions to bring the price of air travel within the reach of an even greater customer market, and the aircraft have fulfilled all that was promised for them. How will the expansion be maintained? A glance at the mounting advertising budgets for the jet operating airlines shows increasing sums being spent on publicising the new travel system. To a great extent each competing airline is advertising the same thing, and the customer's choice is decided by the most convenient schedule. Faced with the difficulty of selling similar merchandise it will be interesting to observe which carriers succeed in achieving the greatest traffic expansion, and what features dictate the customer's choice.

An atmosphere of optimism reigns within the industry, the future appears unlimited; in the circumstances it would be churlish not to take the opportunity of saying "A Happy Second Birthday." ⟷

A preview of the future in passenger embarkation and unloading. American Airlines' new boarding system at San Francisco International Airport. The two mobile gangways are positioned at the doors, and the aircraft is loaded in three minutes.

Jet Operations

At London Airport the *Comet 4's* exceptional climb performance is less vital than at many small airports on the Far East route, which are enclosed by mountains.

BOAC Flies British

When BOAC took delivery of the last of its 19 D.H. *Comet 4s* early in January this year, Managing Director Basil Smallpeice said at the handing-over ceremony at London Airport: "Our operations with the *Comet 4* since the first two of these aircraft were delivered to us on 30th September, 1958, have been remarkably successful. Between that date and 9th January this year our *Comet 4s* have flown 436,932,000 passenger-miles. During that time, the passenger load factor on our North Atlantic *Comet* services has been approaching 90 percent and on our widespread Eastern services some 75 percent. The actual number of passengers carried was 120,000. The revenue aircraft miles flown by *Comets* amount to 10,900,000, representing 27,160 revenue flying hours."

Had the British people in the mid-forties been able to look into the future and foresee this triumphant announcement, many harsh words on equipment policy in British air transport would have been left unsaid. For at that time, despite preoccupation with the war, there was serious — and justifiable — concern as to the path to be followed by air transport when peace returned. It was an undeniable fact that Pan American had beaten the British national company Imperial Airways in 1939 in the competition for trans-Atlantic traffic. And the British carrier's successor, BOAC, lacked not only aircraft capable of crossing the Atlantic, but, what was even worse, high-performance medium-range aircraft for Commonwealth services to Africa and the Near and Far East.

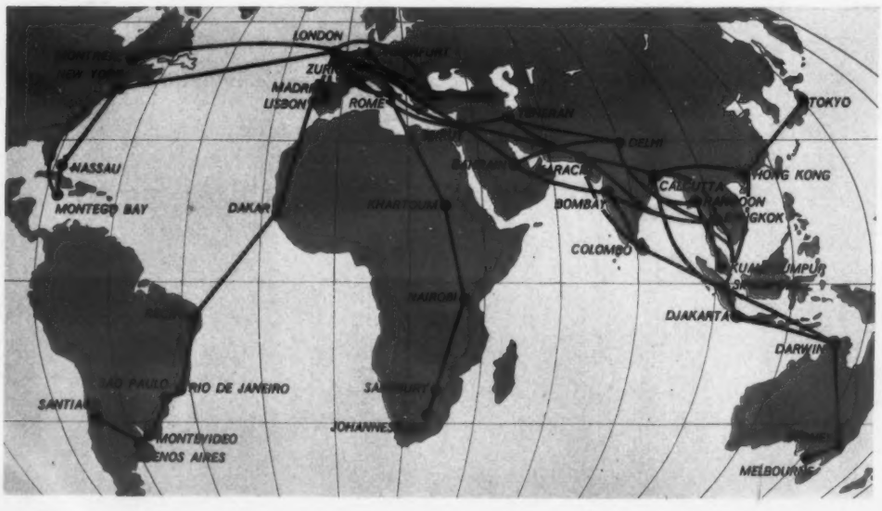
"I hold the view," said Viscount Bennett to the House of Lords in a debate on post-war aviation in 1943, "that if we are not to sink to the level of a second-class Power we have got to have an air transport service now. By 'now,' I mean just that—now."

One year later, at a banquet held to mark the silver jubilee of British air transport, Lord Brabazon of Tara addressed Sir Archibald Sinclair, Secretary of State for Air, in anything but festive terms: "You are being manoeuvred off the earth by what is happening. If you are playing for a fall, you are going about it the right way. That is all I have to say to you, Mr. Secretary of State."

Such was the unpromising start of British air transport at the end of the war. There followed years of toil and courageous endeavour. And today? By October, 1958, BOAC had won the "Second Battle of the Atlantic"—even if only by a neck. More important to Britain, however, was the fact that she had in the *Comet 4* an aircraft which, in its true field of operation, namely medium-haul transport, need fear no competition from the big jets. British air transport has learned a lesson from the false moves of earlier years and seems this time to have discovered an economically sound solution.

Nothing left to chance

In preparing route operations BOAC left no stone unturned and took its time in choosing aircraft type and crews. As early as September 16th, 1957, a full year before scheduled services were inaugurated, the *Comet 2E* plied between London and Beirut on route proving and training flights



In fifteen months BOAC has built up a *Comet 4* route network which extends to all five continents and offers a great variety of north-south routes on the Far East services. The following are the dates on which the routes were opened:

BOAC Comet Services from London Airport

Date of Inaugural Flight	*Destination*	*Weekly Frequency (Winter 1959/1960)*
October 4th, 1958	New York	7
December 19th, 1958	Montreal	1
April 1st, 1959	Tokyo	5
June 1st, 1959	Hong Kong	3
August 10th, 1959	Singapore	1
November 1st, 1959	Sydney/Melbourne	5
December 2nd, 1959	Johannesburg	4
January 25th, 1960	Buenos Aires/Santiago	2
February 2nd, 1960	Montego Bay	6

whose frequency, thanks to the collaboration of the Ministry of Supply, was raised to 11 flights per week.

In May, 1958, there began a second phase in the preparation of trans-Atlantic traffic. Initially, ten crew training flights were made between London and Gander. Later, alternate airports with names familiar from piston-engine operations were reconnoitred from Gander: Monckton, New Brunswick; Sydney, Nova Scotia; Goose Bay, Labrador; Stephenville, Newfoundland etc.

The two trial *Comet 2Es* were in the air for a total of 3,725 hours. BOAC's firm resolution to run no unnecessary risks paid off in the first year of operation by a relatively high degree of punctuality. Of all the *Comets* flying the North Atlantic route, 50 percent arrived at their destination within 15 minutes of the advertised time, and 83 percent of flights arrived within one hour of schedule. The corresponding figures for Far East operations are 44 and 66 percent.

This gratifying result naturally says much for the qualities of the aircraft and its Rolls-Royce *Avon Mk.524* engines. Neither the manufacturers nor the Air Registration Board found it necessary to limit the *Comet's* operations or to forbid take-off. According to BOAC personnel, the only serious disturbances were caused by birds, such as the storks at Colombo, which have, say the bird-watchers, the habit of cooling their feet in rain puddles on airport runways and letting themselves be ingested by air intakes.

First across the herring-pond

After the BOAC *Comet 4's* maiden flight on April 27th, 1958, the Anglo-Saxon press, in characteristic fashion, began to lay bets as to which company would be first to fly passengers across the Atlantic in a jet, Pan American or BOAC.

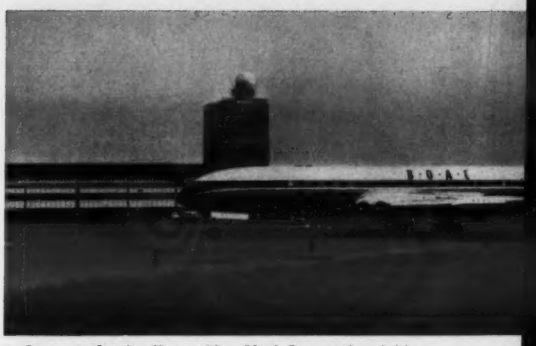
As late as mid-September, 1958, a headline in the Financial Times ran: "PAA First on Atlantic with Jets." And a few days later Pan American announced its intentions of inaugurating a New York–Paris–Rome jet service on October 26th. But BOAC remained unperturbed, even when, with three *Comets* already delivered and all set for take-off, the American authorities delayed permission until the last moment. Late in the evening of October 3rd clearance was received from the Port of New York Authority, and early on October 4th two BOAC *Comets* took off from London Airport and New York International Airport on the first scheduled trans-Atlantic jet flights. It goes without saying that the two commanders, Captain R. E. Millichap and Captain T. B. Stoney, exchanged greetings by radio and that the throats of passengers and crew, if not their eyes, were suitably moistened in honour of the occasion.

Next came the second part of the programme which, though less spectacular, is possibly more significant: Hong Kong, Tokyo, Singapore, Melbourne, Johannesburg ... In 1959 BOAC inaugurated the Commonwealth jet route network, for which the *Comet 4* is particularly well suited. For long runways are scarce in the Middle and Far East. Out of a score or so of airports on BOAC'S Far East routes only two, Teheran and Bangkok, have 10,000 ft runways, while the runways at most others are barely 7,000 ft long, and some, such as Colombo (6,500 ft) and Kuala Lumpur (6,000 ft), considerably less. And it should not be forgotten that the aircraft have to take off in tropical heat. It was easy for the *Comet*, with its amazing rate of climb and its low runway requirements, to follow in the footsteps of the *Britannia 102*. The big jets cannot, however, be "sent into the backwoods."

As for the passengers, who are the whole *raison d'être* of the service, only an infinitesimal number fly all the way from Europe to the Far East, and faces change with airports. In order to keep their aircraft as full as possible, operators are in many cases compelled to call at certain airports alternately. A good example is BOAC's Far Eastern route which, as the map shows, is not so much a route as an artery with many branches. The *Comet 4* has a layout of 20 first-class and 43 tourist-class seats on these services. Its break-even load factor is about 50 percent. In other words, 10 first-class and 23 tourist-class passengers are enough to avoid a loss. The big jets, designed to carry 160 to 180 passengers, would not make such a good showing under the operating conditions just described.

Across the Atlantic, on the other hand, the *Comet 4* is likely to find the going somewhat harder when the big jets are in full operation, though for the time being the North Atlantic load factor is still 80 to 90 percent (see table). In 1959 BOAC succeeded in outdoing TWA, winning second place in respect of passengers carried among all the companies flying the North Atlantic. In the first twelve months of *Comet* operations BOAC's dollar earnings were up by 32 percent over the previous year.

Is is clear, however, that no passenger will be particularly anxious to stop at Gander, Shannon, Recife or Dakar when he can be taken direct from London or Paris to the major cities of the New World. BOAC Managing Director Basil Smallpeice no doubt had this in mind when he vigorously advocated reductions in air fares: "... BOAC reaffirms its belief that the cost of air travel can and must be reduced if we are to take advantage of the enormous work capacity of the modern jetliner and make air travel available to many millions of people who cannot afford the present level of fares." ←→



A *Comet 4* after landing at New York International Airport.

Even Kuala Lumpur, the capital of Malaya, can be approached without difficulty in spite of its runway of only 6,000 ft.

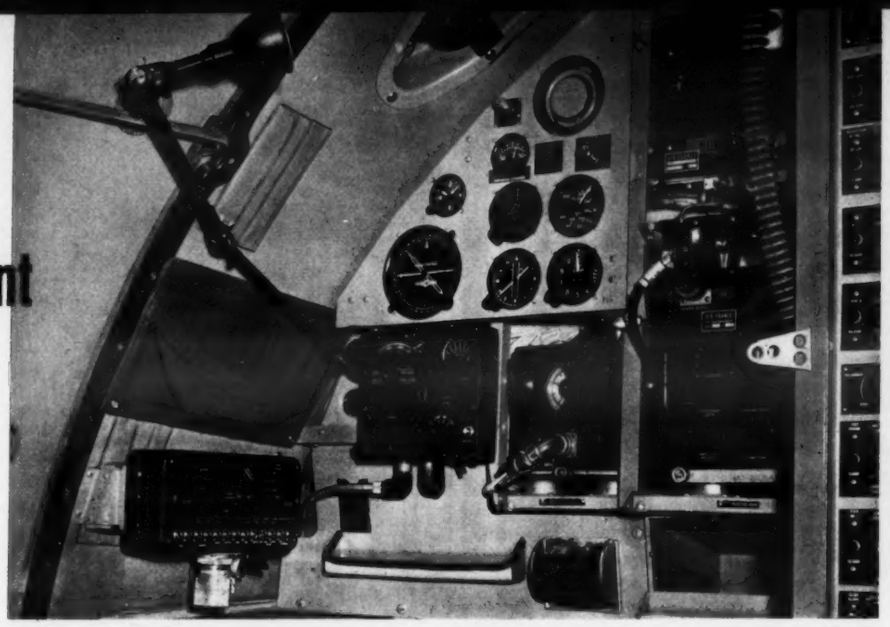
BOAC Passenger Load Factors on Jet Services

Average for 4 weeks ending	*(from London to...)*				
	USA	*Canada*	*Japan (via northern India)*	*Singapore*	*Malaya*
1958/59					
Dec. 13th	87.1	—	—	—	—
Jan. 10th	72.5	—	—	—	—
Feb. 7th	74.8	—	—	—	—
Mar. 7th	82.0	58.5	—	—	—
Apr. 4th	88.8	72.5	—	—	—
May 2nd	91.3	87.8	66.7	—	—
May 30th	93.7	97.1	74.4	—	—
June 27th	88.3	73.3	72.9	80.2	—
July 25th	74.0	53.9	83.9	89.9	—
Aug. 22nd	70.9	57.1	69.1	87.9	72.5
Sept. 19th	85.7	86.2	67.2	90.2	79.9
Oct. 17th	89.0	89.7	75.6	86.9	79.7
Nov. 14th	90.2	91.1	62.4	72.4	65.9

BOAC's maintenance depot at London Airport.

Navigation Equipment for Swissair's Jets

By H. Krähenbühl, Chief Navigator, Swissair, Zurich



Navigator's position in a piston-engine aircraft; lower row of instruments, left to right: radio-compass, radio altimeter, older model Loran receiver.

When we ordered our new long-range aircraft some four years ago, we were already well aware that conventional navigation systems would not fully meet the requirements of jet services. Not only are cruising speeds almost doubled, but a great many other changes are also introduced: altitudes lie around 40,000 ft, ranges are longer, fuel consumption is tremendous and hence take-off weights are more than 100 percent higher. The utilization of these aircraft is therefore a challenge to the experts, who must constantly develop new procedures and systems in order to derive the utmost benefit from all potential navigation methods.

Every navigation system has the primary task of giving the crew continuous information on ground speed, drift angle and position. This must always be done as accurately and as rapidly as possible. It is clear, however, that a DC-4 is not nearly so demanding as regards "delivery times" as a DC-8, for example. In jet aircraft, navigation information must wherever possible be made available automatically, continuously and without delay.

In 1956, when Swissair decided to order its first jets, the following new navigation systems were known: Dectra, doppler radar, automatic star trackers and an advanced form of Loran. Of these methods and equipments, the automatic star tracker had to be eliminated from the outset, since it was still on the secret list. Swissair and Scandinavian Airlines System, however, jointly decided to put the other three systems through a series of strenuous tests, with SAS investigating the doppler system, and Swissair the Dectra and Loran methods.

Dectra

Our tests gave us an opportunity to investigate the accuracy and reliability of the system in regular airline service and to gather experience of its range on the following stages:

Shannon–Goose Bay	Lisbon–New York
Shannon–Gander	New York–Cologne
Shannon–New York	New York–Geneva
Lisbon–Gander	New York–Zurich

The equipment which *Decca Navigator Company* provided for these tests consisted of a Dectra receiver and a Decca Mark 7B. It was installed in a DC-7C, and the tests were carried out during the period January 31st to July 23rd, 1958. A total of 115 Atlantic crossings was made, with the results shown in *Fig. 1*.

It should be noted that the Dectra maps covered the whole of the area of interest to us, and the dispatchers experienced no difficulty in entering the planned route. On the European side of the Atlantic the equipment could be properly synchronized for tracking signals only at Shannon and occasionally at Lisbon. In 16 cases it was found that tracking signals were not received between Shannon (9° West) and 20° West, particularly during twilight periods. In New York reception of tracking signals was always satisfactory. Ranging signals were well received both in Shannon and in Lisbon and on west-bound flights remained utilizable up to longitude 55° West. On east-bound flights, however, ranging signals did not become strong enough until between longitudes 50° and 45° West.

Within the range of the Dectra system *accuracy was found to be exceptional*, and was not affected by either precipitation or static. However, during twilight it was occasionally observed that the Flight Log pen suddenly drew a non-existent deviation from course. To sum up, it can be said that under good conditions the Dectra system works very much more accurately than other navigation systems, but unfortunately its range is not sufficiently great for our North Atlantic services.

Doppler radar

This extremely interesting navigation system can, as is known, continuously indicate ground speed and drift angle, so that any change in these values can be ascertained without delay. An additional advantage is its complete independence of all ground installations. When used in conjunction with a computer, the system also sup-

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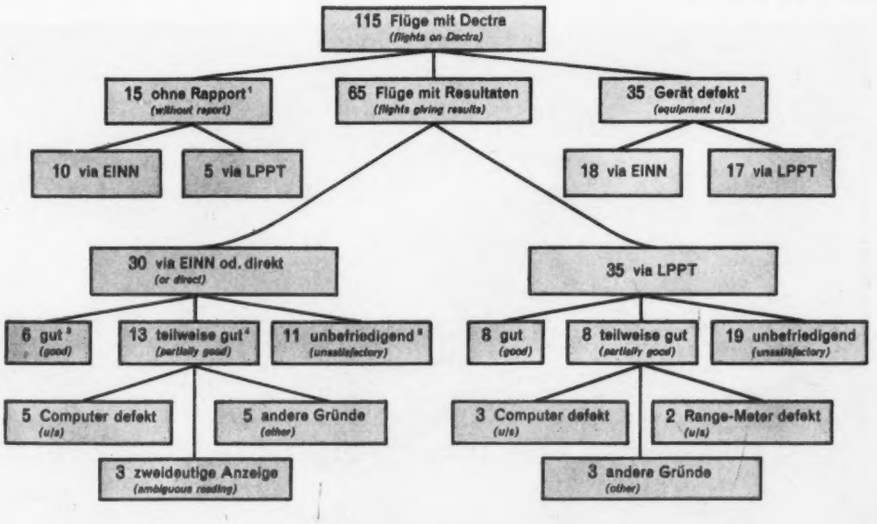


Fig. 1: Results of Swissair's trials of the Dectra system, covering a total 115 Atlantic crossings.

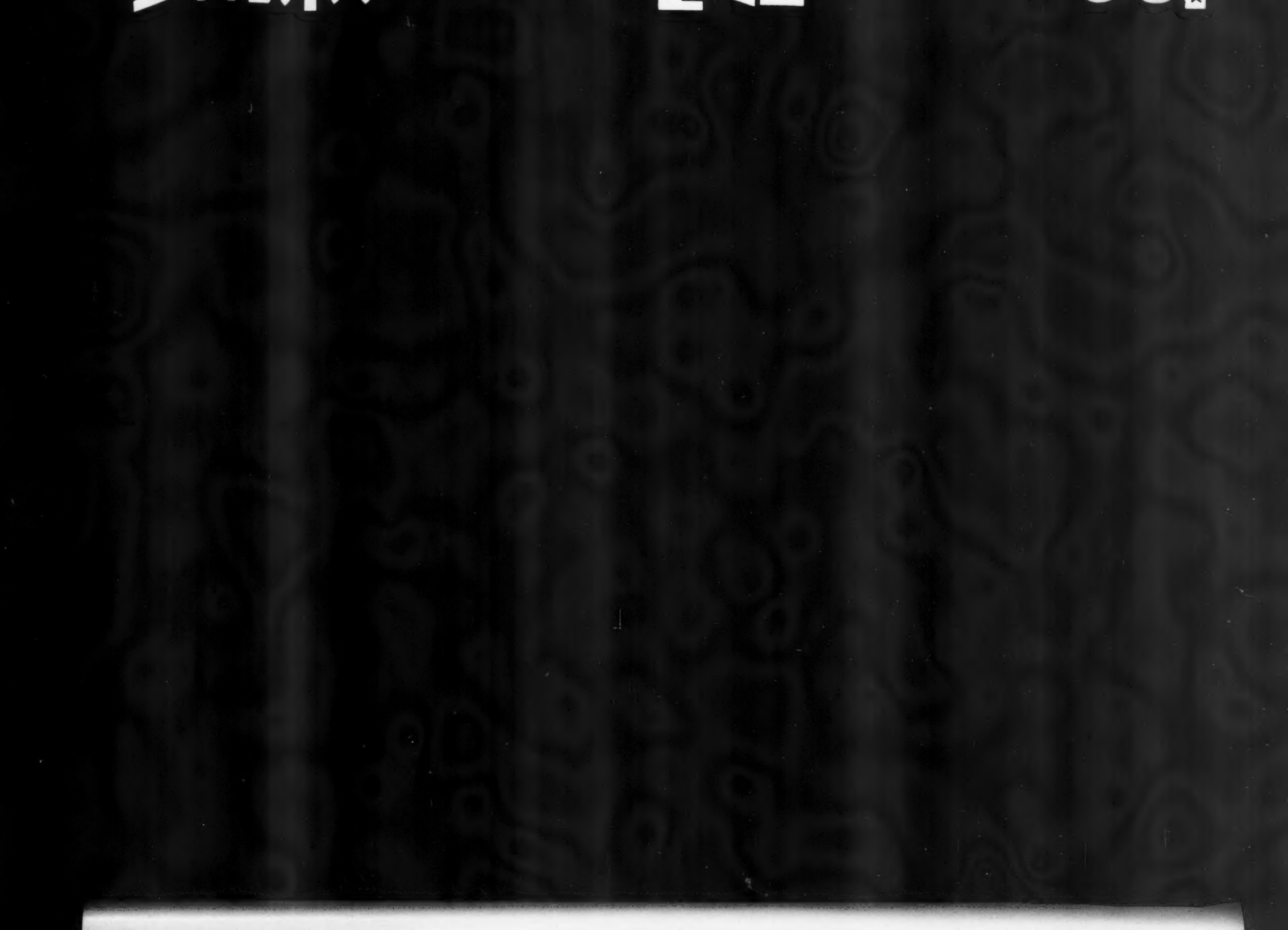
1 Either the crew had no training, or the equipment could not be monitored for other reasons.

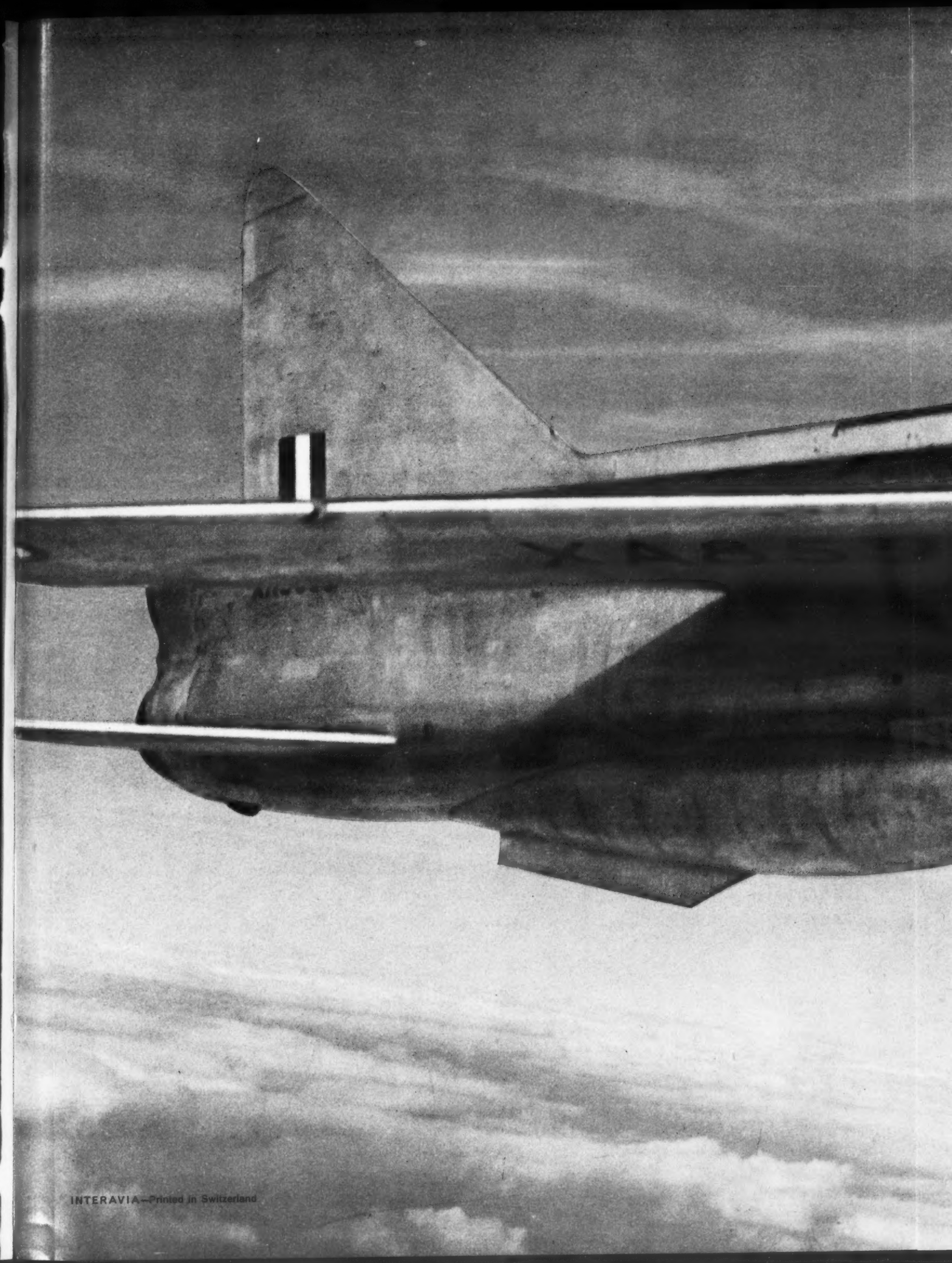
2 Equipment unserviceable on take-off.

3 Good: the equipment functioned correctly, and the results obtained would have permitted navigation by Dectra alone.

4 Partially good: despite isolated deficiencies, results would have permitted use of the system.

5 Unsatisfactory: signal loss or other reasons which would not have permitted exclusive reliance on the system.





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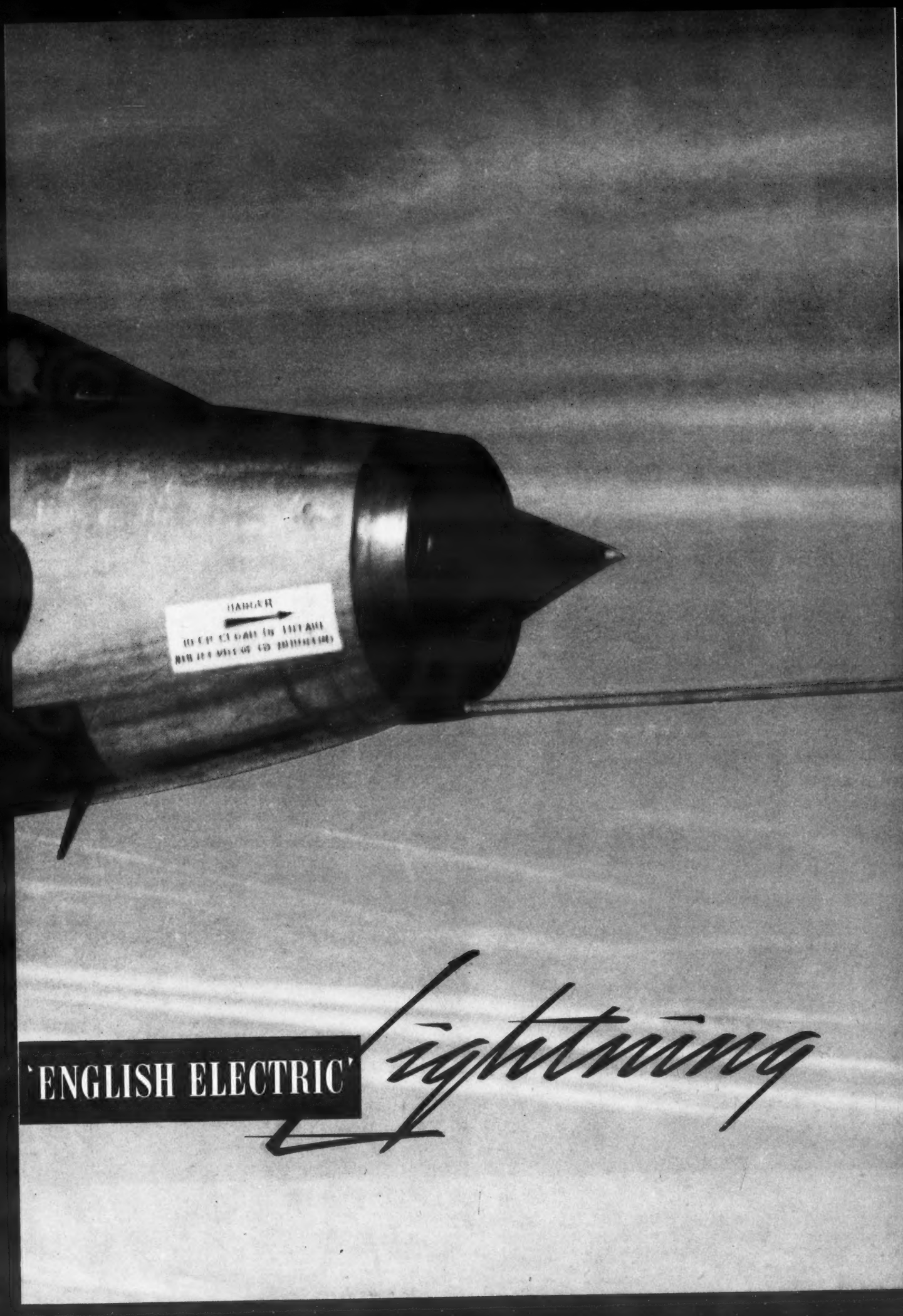
'ENGLISH ELECTRIC'
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XUM

What NATO needs — th

WIDE SPEED RANGE

Designed to give high-level supersonic performance as a fully integrated weapon system, the Lightning has a top speed in excess of Mach 2 yet is completely controllable over a speed range greater than thirteen to one. It loses none of its outstanding flying characteristics in subsonic or transonic flight.

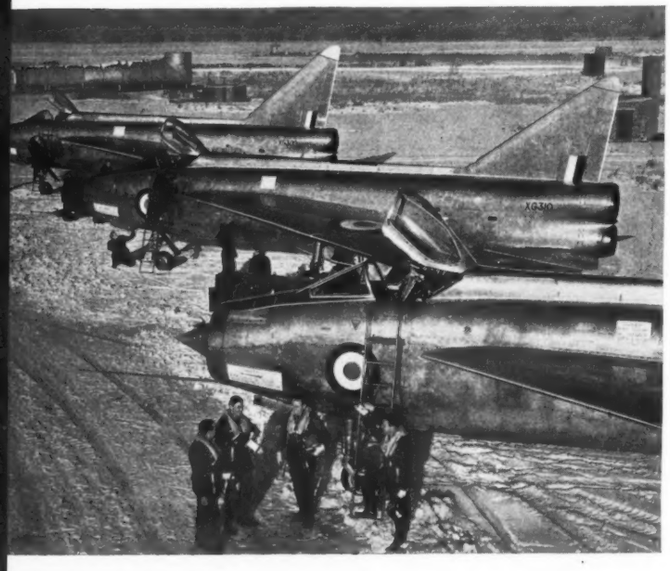
ALL-WEATHER OPERATION

The Lightning has been designed as an all-weather day or night interceptor. Its comprehensive instrumentation, versatility and superb flying qualities enable it to fulfil its role safely and efficiently under all climatic conditions.

OUTSTANDING PERFORMANCE

The Lightning reaches a speed of Mach 0.9 in level flight at operational height within 2.5 minutes from brake release. In considerably less than 3.5 minutes it can accelerate from the speed of sound to Mach 2.

At all altitudes the Lightning is highly manoeuvrable and fully aerobatic whether subsonic or supersonic; such outstanding performance makes the aircraft suitable for a number of roles including Ground Attack and Photo-reconnaissance.



the "Lightning" has .... *Now*

TWIN ENGINES FOR RELIABILITY AND ECONOMY ... Two engines to provide reliability are a vital requirement in a supersonic fighter aircraft.

An added safety factor in the case of the Lightning is the positioning of both engines along the centre-line of the fuselage so that the aircraft does not develop asymmetric characteristics when flying on one engine.

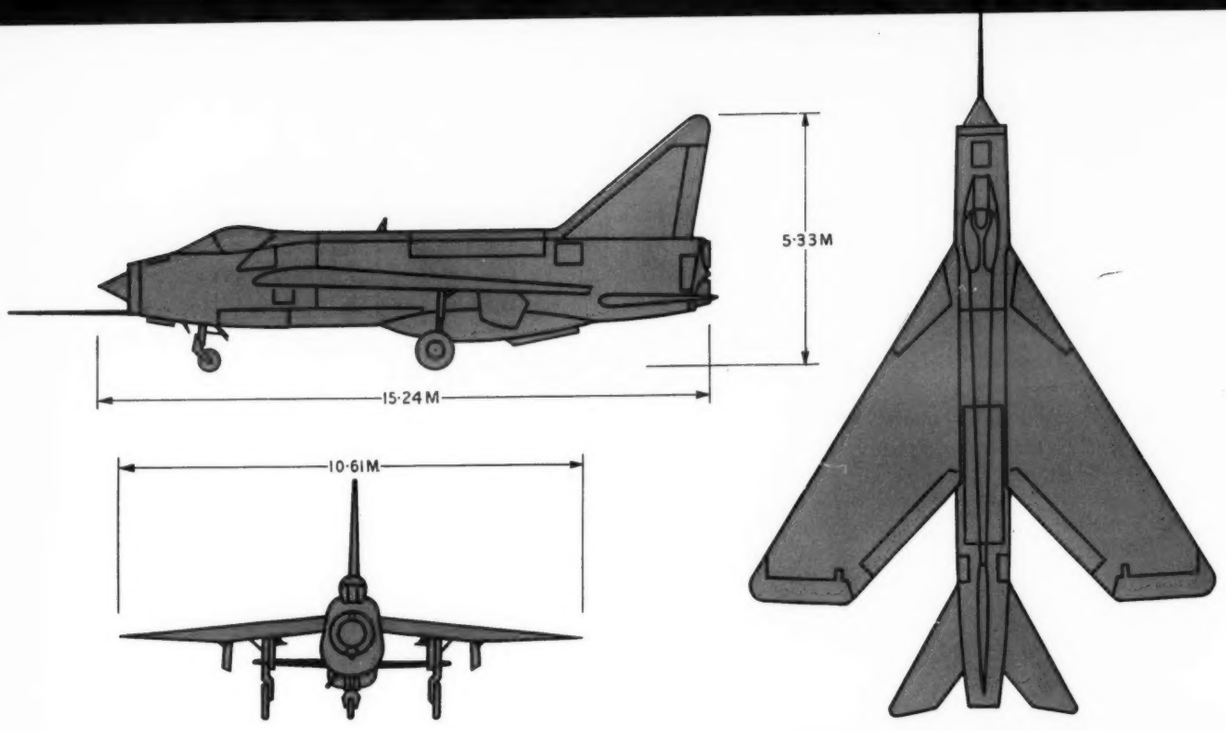
Further reliability on the Lightning is provided by complete duplication of all power control systems and their associated power supplies.

The two Rolls-Royce Avon engines provide supersonic performance without re-heat and afford great fuel economy under appropriate conditions.

Two-seat version now available

The two-seat version of the Lightning now available has all the outstanding qualities of the single seat version and a comparable performance. It can be used as a trainer, for conversion purposes, or as an operational aircraft... or this same aircraft can fulfil all these functions.

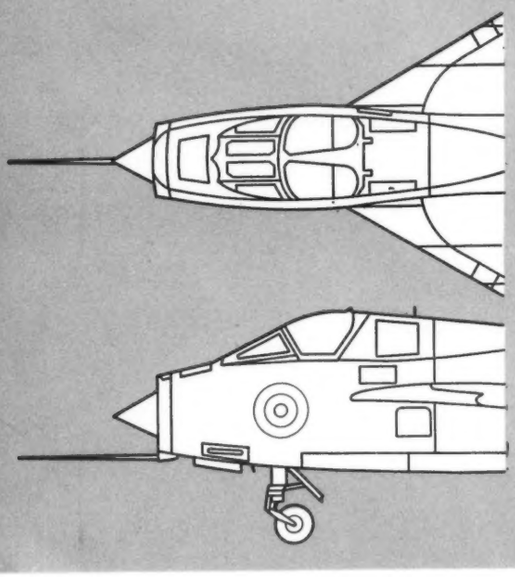
In its operational role the pilot can give full attention to



his instruments while the radar operator takes over fire control responsibilities.

The two-seat Lightning is equipped with the same full navigational and landing aids, airborne search and track radar as are fitted to the single seat version.

All controls and instruments including Radar Fire Control are duplicated.



AN INTEGRATED WEAPON SYSTEM

The engines, airframe, radar equipment, the electronic aids, the armament, the fire control devices—all were planned from the start to work as a co-ordinated whole to achieve maximum operational performance.
A variety of armaments can be fitted to meet different operational requirements—all are developed within this integrated weapons concept.

INHERENT AERODYNAMIC STABILITY

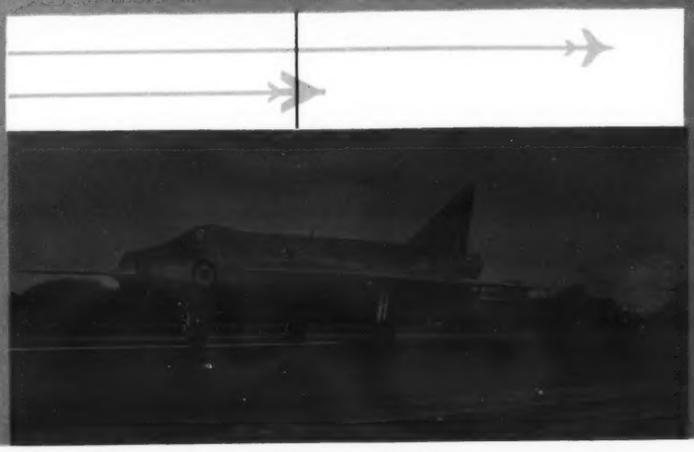
Ease of control at all speeds is achieved without autostabilisation; the Lightning does not depend upon electronically supplied stability. Autostabilisation is there—but needed only as a refinement in the tracking and attack phases.
All this has been achieved because the design of the aircraft is such that it is inherently aerodynamically stable and completely free from pitch-up throughout its entire performance range.

DEVELOPMENT POTENTIAL

The Lightning is only at the start of its great potential. This basic design offers great possibilities not only for increased performance but also for adaptation to other roles. This potential ensures great economies in operation.

EASE OF LANDING

No complicated landing techniques need be learned nor any extensive runway alterations made, for the Lightning can be landed and brought to rest in 800 yards.



English Electric Aviation Limited Marconi House, Strand, London WC2

V15
MAR
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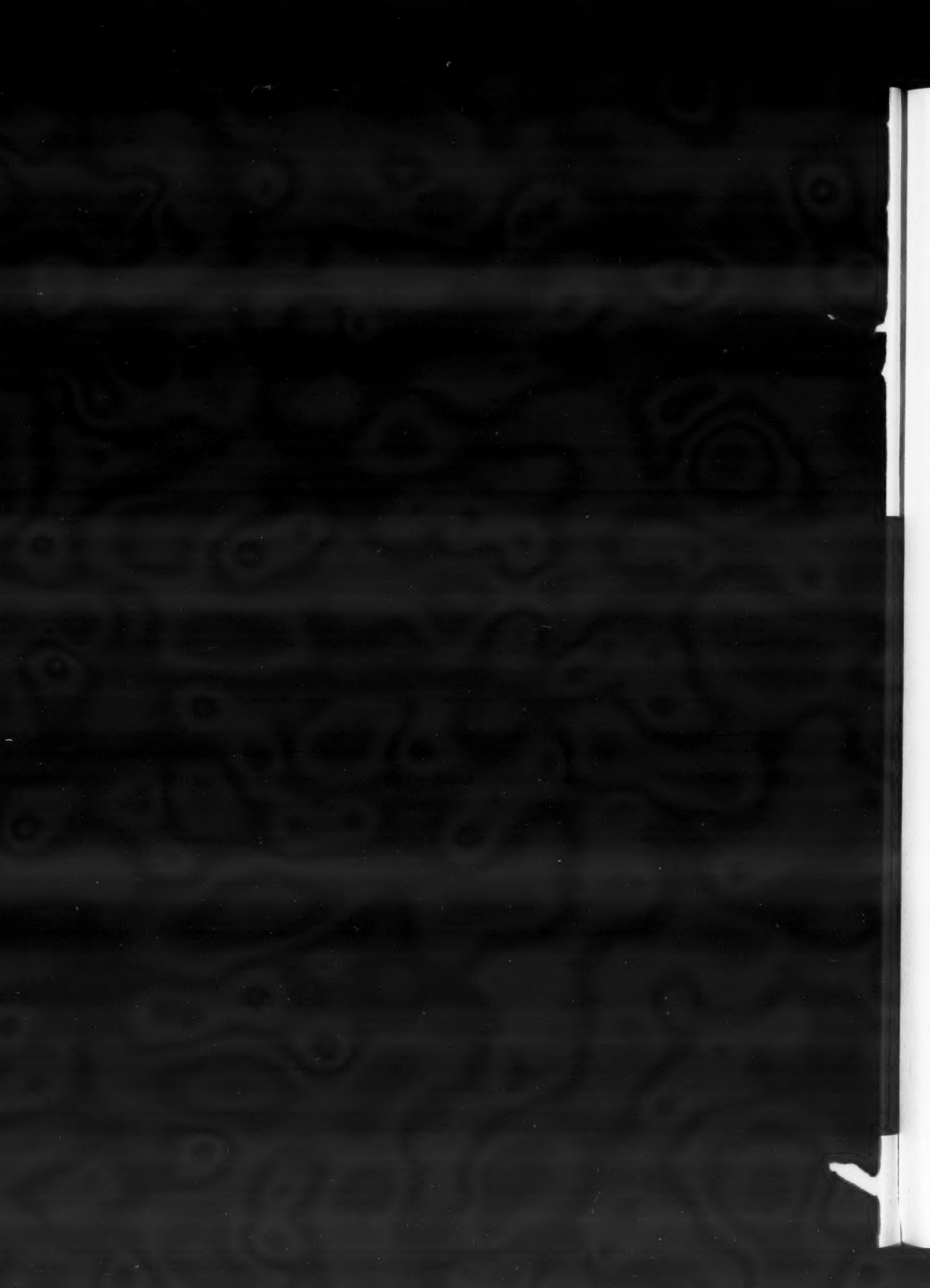
XUM



plies other data required for the flight, in particular the distance to go to the next check point and any deviations left or right from the desired course.

As Douglas had allowed for the installation of two doppler equipments in each DC-8, all that remained for us to do was to select the model. This was no easy task, as practically every manufacturer uses different design principles. We had a choice between CW, FM/CW and pulse equipments, as well as between installations with fixed or rotating antennas. SAS therefore worked out a comprehensive test programme designed to assess the most promising make. Doppler equipment was fitted in DC-7C aircraft and used throughout the SAS network. To ensure that comparable results were obtained from all tests, a team of eight navigators was specially trained for the purpose. Distances and track angles for the individual stages were also accurately determined and set out in table form. Reference points used were airport runways or beacons, and the course information fed into the doppler radar was very exact. Admittedly, SAS had an unusually reliable source of heading information in the Polar Path Compass System, which can also be adjusted for either magnetic course or grid course. When flying on grid navigation, the final reading for lateral course deviation had to be corrected by the amount of the gyro precession indicated by the gyro log, while for flights on magnetic headings the mean variation for the route had to be taken into account. The computer for the doppler system was switched on either on take-off or when a given beacon was passed, and all final cross track and along track readings were also recorded over a beacon or on the runway at the airport of destination.

The results of the tests with one of these doppler installations are shown in *Fig. 2*, which covers a total of 76 stages with an average length of 1,198 nautical miles. *Fig. 3* then gives the instances of unsatisfactory performance in cruising flight for the same equipment, i.e., loss of signals because of calm seas (below sea state 3) or extreme fluctuations when flying over mountainous regions. On one occasion over the North Atlantic a period of 71 minutes was noted when all signals were lost.

The tests so far carried out have revealed what tremendous latent possibilities there are in this system of navigation, but have not yet been sufficiently convincing to justify the immediate installation in jet airliners of such doppler equipment as is available on the market today. This conclusion is also confirmed by experience of doppler radar aboard the Boeing 707. At the high altitudes at which jet aircraft operate, loss of signals above the ocean is particularly frequent. However, these difficulties should be overcome in time. In any case, as soon as a reliable doppler radar appears on the market, we would fit it in the place already allowed for it in our jets. This does not, of course, mean to say that we should then navigate only by the doppler method. The system would first have to gain the confidence of our crews, perhaps the most serious hurdle which any new system must overcome. Airline crews are "professionally" distrustful.

Loran

Loran, which has been proven in many years of service, had no need of the same fundamental testing. We therefore contented ourselves with trying out a new Loran receiver made by *Edo Corporation* and incorporating many improvements over older models. In particular the Edo Loran equipment is substantially lighter in weight than other installations of this kind, it is simpler to operate, receiver and control unit are separate, and receiver sensitivity is greater. The trials gave fully satisfactory results, and the equipment passed its acceptance tests for installation in the new jets.

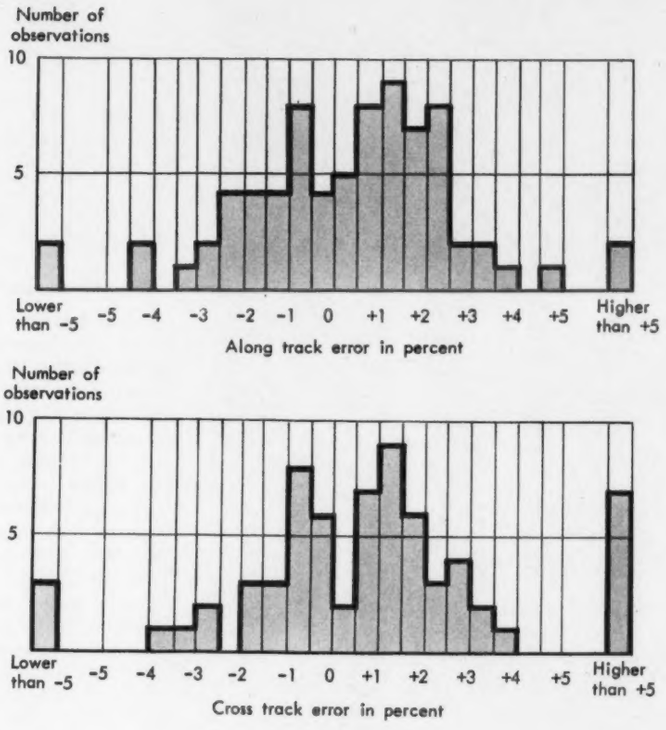


Fig. 2: Results of operational tests carried out by SAS on a doppler system of undisclosed type: top, along track error in percent; bottom, cross track error, also in percent.

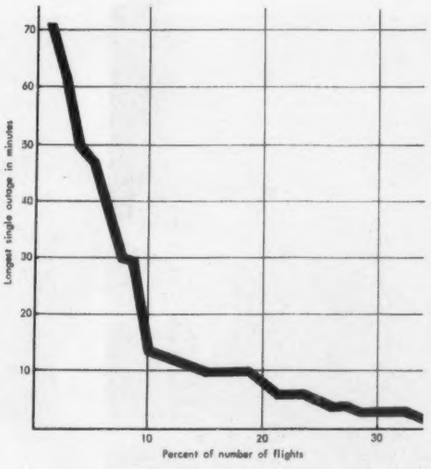
*

As a result of these tests, Swissair's Douglas DC-8s and Convair 600s will initially be fitted with the following navigation equipment for long-range flights:

2 Type C-11 compass systems, to supply either grid or magnetic compass course information;
1 C-2A compass system for magnetic headings;
1 Edo Loran with two control units;
1 periscopic sextant for celestial navigation;
1 sky compass with polarization filter for observation of the sun when below the horizon or obscured by clouds;
1 radio altimeter;
1 weather radar.

To make sure that navigation would be reliable despite the continuing absence of automatic equipment, new aids were developed and certain procedures reorganized. In particular, we decided that the three basic forms of information—position, ground speed and drift angle—would be ascertained as follows:

Fig. 3: Signal losses in the doppler radar tested (time in minutes) plotted against relative frequency (percentage of all flights).

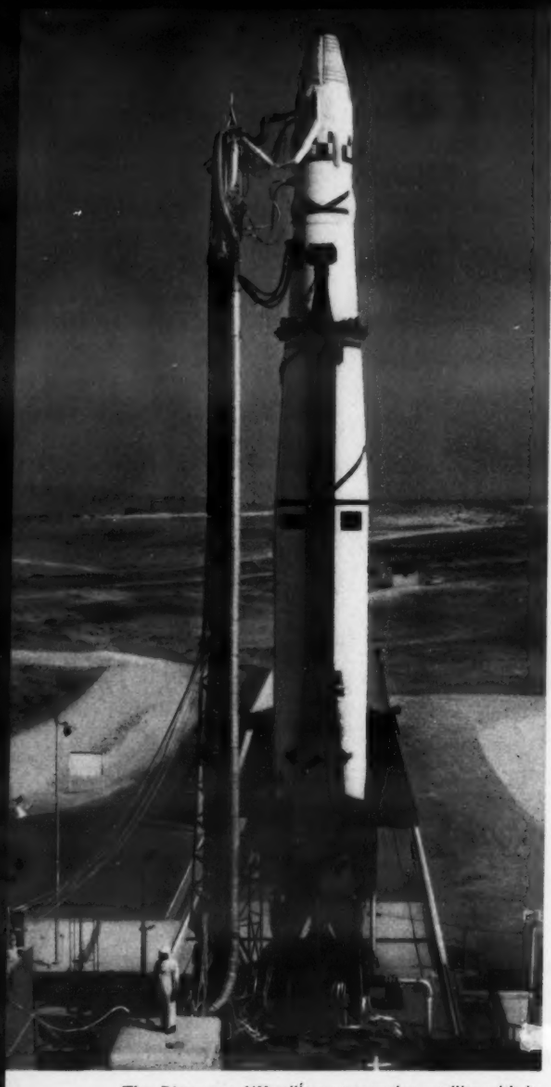


Position fixing: The navigator takes a position fix at intervals of some 20 minutes. Over the North Atlantic, where adequate Loran stations are available, we use mainly Loran. The new Edo equipment enables the values for two position lines to be read off almost simultaneously, and a third reading to be made within a minute. The second method is the well-tried celestial navigation, though this has had to be greatly condensed for jet aircraft. Up to the present the procedure has taken a full 12 minutes from the beginning of the first observation up to final entry of the position on the map. During this time, however, a jet aircraft has covered roughly 100 nautical miles, a distance which renders even the most accurate position fix out of date. Thanks to a modification made by the Swissair workshops to the periscopic sextant, which permits of an observation time of either one or two minutes as desired, and to more refined precalculation methods, the time required for obtaining a position fix by celestial methods has been reduced from 12 to 6 minutes. This is particularly valuable on our South Atlantic routes, where there is no Loran.

Ground speed: This is calculated from the distance between position fixes and the time taken.

Angle of drift: At altitudes between 30,000 and 40,000 ft it is quite common to encounter strong winds, particularly the jet streams. In some cases wind forces of 250 knots have been measured. Obviously, such wind speeds can cause enormous drift. Once again doppler radar would be the most valuable aid, or as a substitute pressure pattern navigation where drift is determined by comparing the readings of radio altimeter and pressure altitude indicator at regular intervals. One disadvantage is that in some equipments the return wave from the radio altimeter disappears in the null signal every 5,000 ft. However, this deficiency has been overcome by the Swissair and SAS workshops, by artificial suppression of the null signal. Finally, we have prepared tables showing drift angle at a glance, to simplify pressure pattern navigation. ◆◆

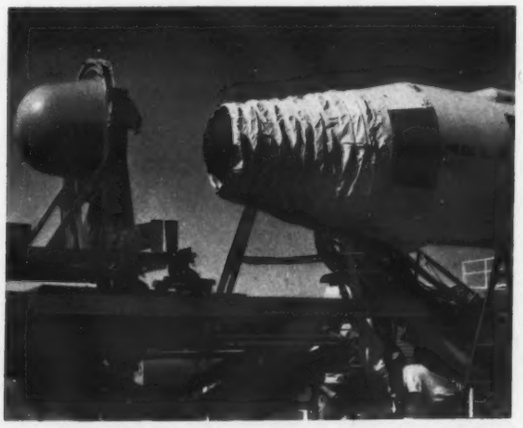
Rockets, Missiles



The *Discoverer VII* military transpolar satellite with its booster on the launching pad at Vandenberg Air Force Base, California. The first stage of the vehicle is a modified *Thor* rocket, the second stage, which contains the satellite, is a Lockheed/Bell *Agena*.

Below left: Engineers preparing the *Agena* second stage of the *Discoverer VII* booster before launching. The recoverable re-entry vehicle containing recording instruments and their data (not shown here) is to be fixed to the tip of the rocket.

Below right: The *Discoverer VII's* recoverable re-entry vehicle (under the cloth covering in the centre of the picture) is attached to the satellite. Left: the re-entry capsule's protective container on its transport trolley.



NASA 1961 Budget

Funds totalling $802 million are allocated to the U.S. National Aeronautics and Space Administration (NASA) under the budget estimates for fiscal 1961; this represents an increase of 53 percent over the $523 million requested for NASA in the current fiscal year. The most important NASA project under the new budget is the *Saturn* booster; NASA is requesting $140 million for this project and for the giant *Nova* booster. A few weeks ago the President ordered NASA Administrator T. Keith Glennan to accelerate the development of high-thrust space vehicles, so that additional funds for work on *Saturn* and *Nova* may shortly be requested. Under present plans the *Saturn* is to be launched on its first space missions in the winter of 1964/65.

NASA's second largest project in fiscal 1961 will be the *Mercury* manned satellite capsule; the total cost of booster and auxiliaries during this period will be $122,750,000, including $15 million for the global tracking network. These stations, which will ultimately cost more than $60 million and are scheduled for completion this year, will track the capsules on their orbits around the earth and, if necessary, provide remote control. Stations will be set up in Florida, the Caribbean, Bermuda, the Canary Islands, Nigeria, Zanzibar, Australia, Canton Island, Hawaii, southern California, New Mexico, Texas and on two ships in the Indian and Atlantic Oceans.

Atlas Launching Sites

The following launching sites have been selected for the four additional *Atlas* squadrons requested by the President: Altus AFB, Oklahoma; Dyess AFB, Texas; Walker AFB, New Mexico; and Plattsburgh AFB, New York. Each base will have nine dispersed underground silos with launching pads hardened to 100 p.s.i.; each installation, including all auxiliary equipment, will cost about $47 million and will require two years for completion.

Minuteman Test Firing

At the end of January a prototype of the *Minuteman* solid-propellant ICBM with a Thiokol first-stage motor and dummy upper stages was fired for the first time from its 100-ft deep silo at Edwards AFB, California. Nylon cables halted the missile in its flight a few hundred feet from the ground. The prototype was fitted with a new stabilization and guidance system, which will also control the launching and climb of the missile in the production version.

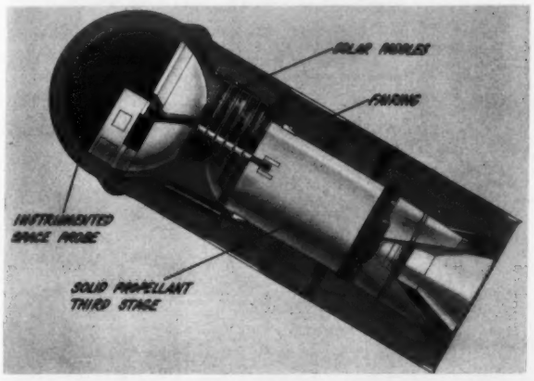
Mauler Surface-to-Air Guided Missile

The U.S. Army is reportedly nearing a decision on the development of the *Mauler* air defence missile, on which Convair, General Electric, Martin and Sperry Rand Corporation completed feasibility studies over a year ago. The rocket-powered *Mauler* is designed to be larger and faster than the Convair *Red-Eye*, to have a longer range and to use a self-contained fire control and guidance system instead of an infra-red system. Whereas *Red-Eye* is designed for one-man operation in advanced infantry units, *Mauler* is a two-man weapon for truck or jeep mounting and is primarily intended for mechanized columns.

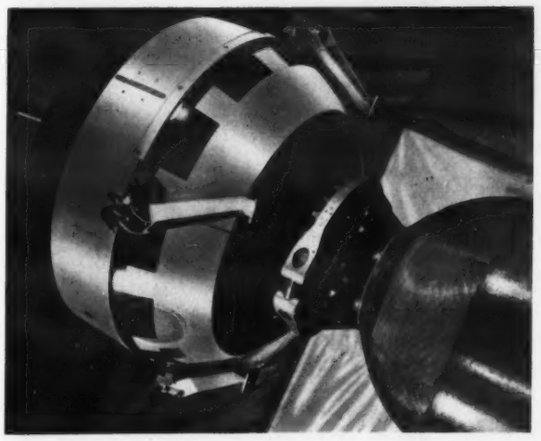
Project Wagmight

The Navy Bureau of Weapons has prepared specifications for an inflatable aircraft-missile, known under the name Project *Wagmight*. The vehicle, which could carry a warhead, serve as decoy, perform reconnaissance missions or transport supplies, would be powered by two small jets and have a speed of some 500 m.p.h. and a range of 1,500 miles. It could be stored folded up inside a cylindrical container roughly 23 ft long and could be inflated ready for operation within some 30 minutes.

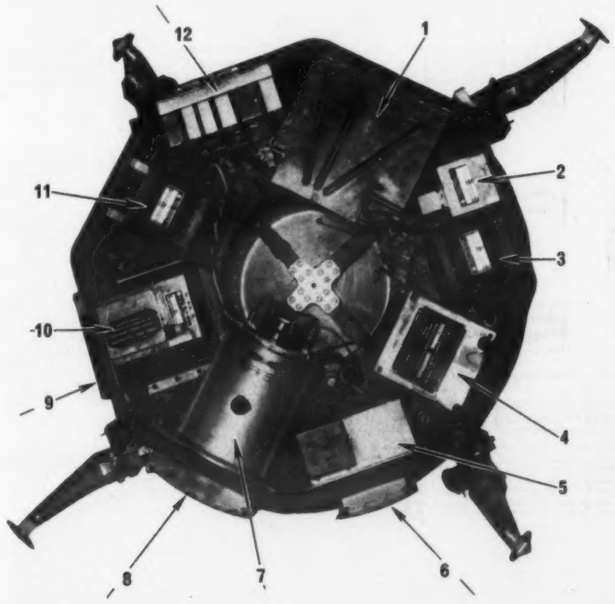
and Space Vehicles

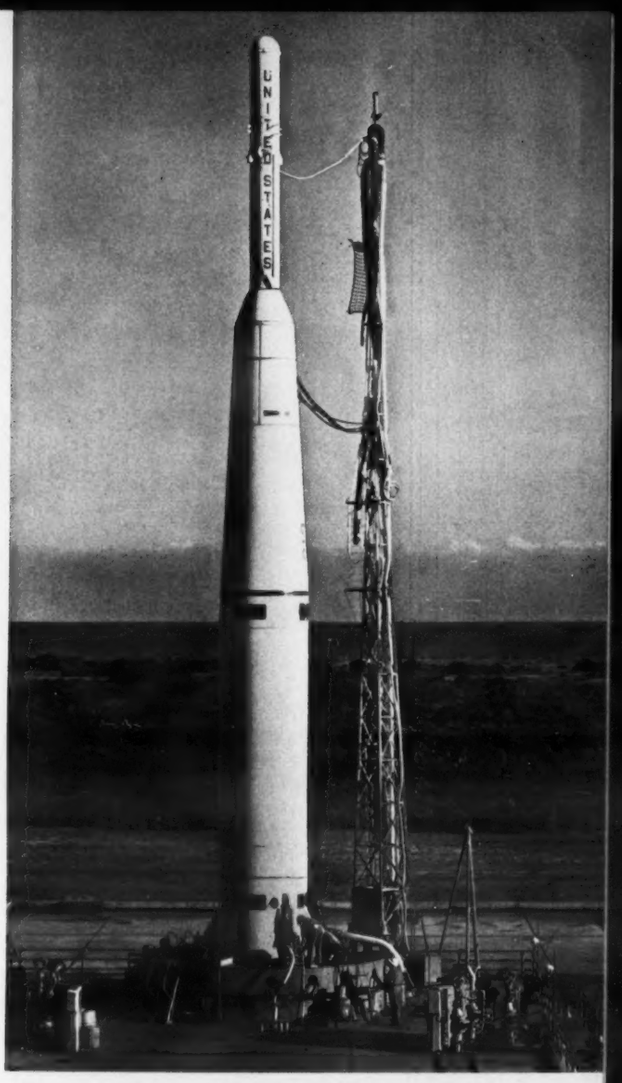


The *Thor-Able IV* paddlewheel satellite with the Allegany X-248A third-stage rocket, which can generate a thrust of roughly 3,000 lb for about 40 seconds and accelerate the payload to nearly 25,000 m.p.h. The photograph shows the sprung arms for the paddlewheels supporting the solar converters; the paddlewheels themselves have not yet been mounted.



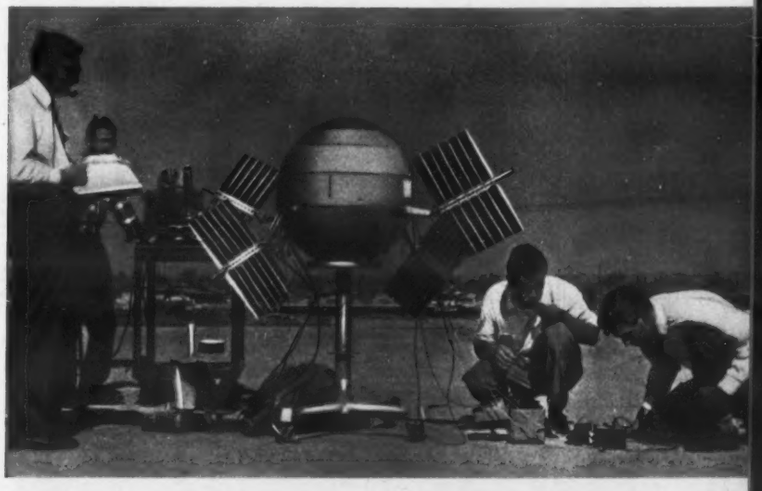
View of the *Thor-Able IV* artificial planet (opened). Mounted on the octagonal instrument platform are: 1 – telebit; 2 – decoder; 3 – batteries; 4 – ionization chamber and Geiger-Müller counter; 5 – converters; 6 – converter heat sink; 7 – 5W/150W transmitter; 8 – transmitter heat sink; 9 – converter; 10 – proportional counter telescope; 11 – batteries; 12 – command receiver. The main tasks in the *Thor-Able IV* programme include measurements of radiation in interplanetary space, micrometeorite measurements, measurements of magnetic fields in interplanetary space and the testing of a photoelectric aspect indicator for taking "fixes" of the sun.





The *Thor-Able IV* booster, weighing over 105,000 lb, towers 90 ft above the Atlantic shores at Cape Canaveral. Its mission is to send a 90-lb NASA space probe on a 295-day trip around the sun. On its orbit, lying between those of Earth and Venus, the artificial planet will have covered a distance of about 90 million miles from Earth nine months after launching.

Technicians at the Space Technology Laboratories Inc. checking the silicon cells of the converters which continuously transform the sun's energy into electric current. This electrical energy is stored in the satellite's batteries and passed in short charges to the transmitters, which operate intermittently.



Streamlining Britain's Aircraft Industry

Bristol Siddeley's high altitude engine test plant can simulate flight conditions at speeds up to 2,300 m.p.h. and altitudes up to 20 miles.

"The aircraft industry must be prepared to face a very tricky period if no new orders are placed, although the Government is doing what it can to keep the industry active." These now familiar words were first spoken by John Freeman, Joint Parliamentary Secretary to the Ministry of Supply in the Labour Government ... at the end of 1948. At that time the situation was "saved" by the advent of the Korean War, which brought a brief period of expansion and prosperity. But before many years had passed new voices were raised in warning: a fresh period of contraction lay ahead; military aircraft were getting more and more complex (hence more and more costly) and obviously could be ordered only in reduced numbers; civil aircraft were facing increasingly hard competition from overseas. Finally, the famous 1957 White Paper appeared to foreshadow the death of the manned combat aircraft and consequently of a large part of the aircraft industry, particularly as without Government backing in the form of military contracts there seemed little hope of being able to keep abreast of rival developments in civil aircraft. Manufacturers therefore found themselves facing the prospect of dwindling markets in all sectors except missiles—and missiles alone could hardly be expected to keep alive an industry that was still employing some 240,000 people. Last but not least, all these problems were aggravated by the lack of any concrete Government programme for the industry.

All this, however, should not be allowed to create the impression that the British aircraft industry has been doing little or no business during recent years. Whatever the fate of domestic sales has been, the value of exports of aircraft, parts, engines and equipment has steadily increased, setting new records year by year. The total figure since 1945 has now topped the £940 million mark, two thirds of which have been earned in the past five years. But here too the future is beginning to look less rosy, and the SBAC forecasts falling exports in the years to come. As it is, though the 1959 figure of £156 million was the highest ever recorded, it was only £2 million above the 1958 total, compared with an increase of £38 million between 1957 and 1958.

It has therefore long been abundantly clear to managements and Government departments alike that "something must be done" to safeguard an industry which has a vital part to play in both national security and the national economy. Both partners have been earnestly seeking a way out and both have taken positive steps which, in their different ways, are expected to lead to a healthier state of affairs.

On the manufacturers' side, one solution has been sought in diversification, as a means of "spreading the load." Companies whose whole past has been devoted to aircraft have been branching out into electronics, agricultural machinery, marine craft and a host of other non-aeronautical products, and this has already done much to strengthen the industry's financial situation. But it still has not put individual companies into the position where they can afford to develop major new aircraft types as a purely private venture.

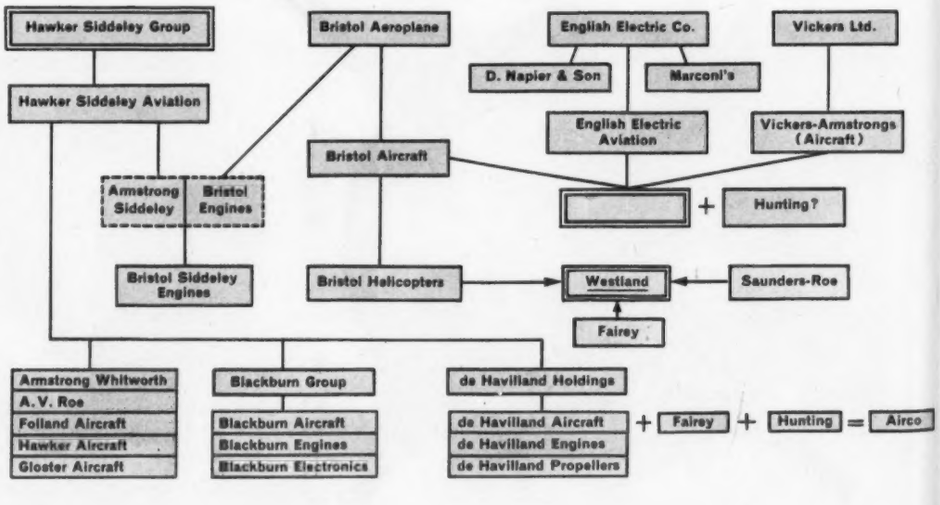
Meanwhile, the Government too has realized that it cannot expect the aircraft industry to maintain its export position, in the face of powerful competition, unless it gives some form of official support. At the same time it has been reluctant to dole out this support in penny packets to a swarm of competing manufacturers, who might or might not come up with a really successful design.

The first public hint of a new Government approach to the problem came in May 1958, when Minister of Supply Aubrey Jones told the House of Commons that the Government intended to continue to contribute towards aeronautical research in the civil transport field, provided the industry reorganized and strengthened itself to meet the changed conditions. But, he added, the Government considered that "the industry should in general be able increasingly to finance the development of new civil projects without Government assistance."

Soon the word "rationalization" began to appear in all discussions of the Government's programme, and gradually it emerged that this meant amalgamations to form two major airframe manufacturing groups and two main engine groups, each with substantial industrial backing. Only then, it was hinted, would official moneys be made available for civil work.

Under this gentle form of pressure events began to move fast towards the end of last year, and already the two major airframe groups are crystallizing: an expanded Hawker Siddeley Group and an as yet unnamed holding company to be formed by English Electric, Vickers and Bristol. The exact composition of these groups is shown in the accompanying diagram.

Diagram I: The composition of the two new airframe groups and the helicopter group. No name has yet been announced for the holding company being formed by Vickers, English Electric and Bristol.



The men behind the news

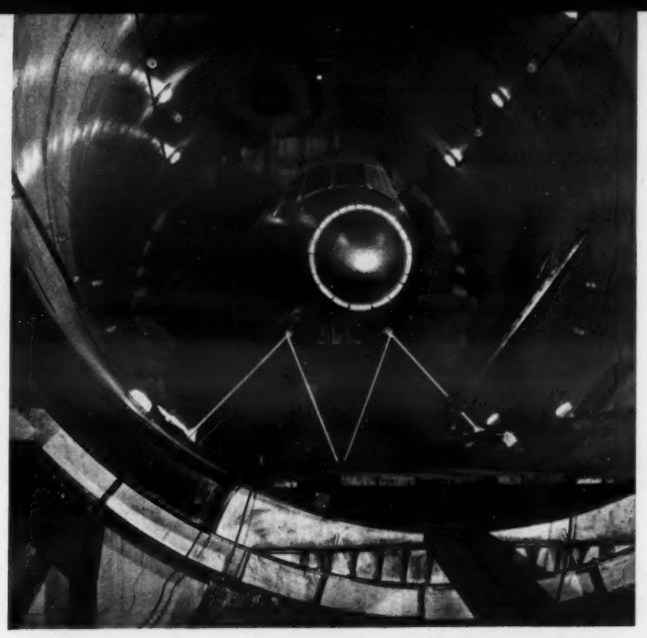
The Right Honourable Duncan Sandys, Minister of Aviation, instigator of the Government's rationalization programme.

The Hawker Siddeley Group's Sir Thomas Sopwith (Chairman) and Sir Roy Dobson (Managing Director—photo by Karsh, Ottawa).

Sir Aubrey F. Burke, Chairman, de Havilland Holdings Ltd., will be appointed Deputy Managing Director of Hawker Siddeley when the merger is completed. — *Right:* Arthur F. Jopling, Chairman of the Blackburn Group since January 1st, 1960, will also join the Hawker Siddeley Board.

H. G. Nelson, Managing Director of the English Electric Company Limited, is also Deputy Chairman of D. Napier & Son Ltd., Marconi's Wireless Telegraph Co. Ltd. and other subsidiaries. — *Right:* Sir George Edwards, Managing Director, Vickers-Armstrongs (Aircraft) Ltd.

Admiral Sir Matthew Slattery is Chairman of Bristol Aircraft Ltd., as well as Chairman and Managing Director of Short Brothers & Harland. — *Right:* Eric Mensforth, Chairman, Westland Aircraft Ltd.



The stratosphere chamber at the Vickers-Armstrongs Weybridge plant. The working section is 50 ft long and 25 ft in diameter.

The Hawker Siddeley Group

The activities of this group in the United Kingdom are divided into two main divisions: Hawker Siddeley Industries Ltd. and Hawker Siddeley Aviation Ltd. General industrial interests cover such products as heavy electrical machinery, motors, generators, diesel engines, locomotives, construction steelwork and buildings, light alloy forgings, castings and extrusions, and in 1958 accounted for some 70 percent of the Group's total business.

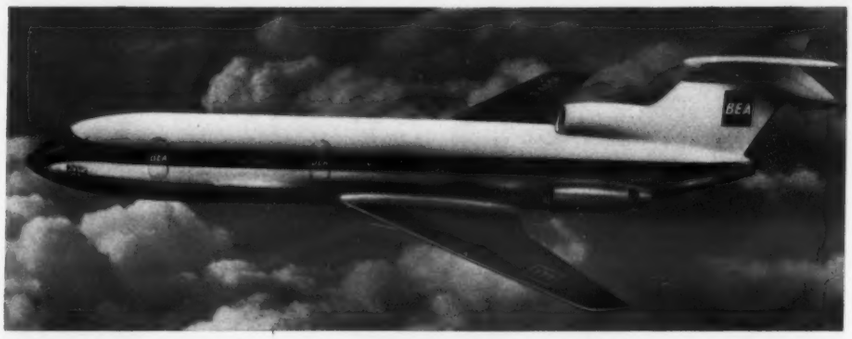
Hawker Siddeley Aviation Ltd., formed in 1958 to coordinate the aeronautical side of the business, purchased Folland Aircraft in the summer of 1959. The end of the year then brought offers from the Group to buy out both the Blackburn Group and de Havilland Holdings. At the time of writing the mergers have not been finally completed, but both the Blackburn and the de Havilland Boards have strongly recommended shareholders to accept the offers. Meanwhile Hawker Siddeley has arranged a £12 million increase in capital to cover the deal.

Apart from aircraft, engine, propeller and missile activities, de Havilland also has interests in plastics, marine craft and bridging equipment, while the Blackburn Group's non-aeronautical companies are engaged in building and civil engineering and the manufacture of such varied items as road rollers, agricultural equipment, motor vehicle spares and general engineering products.

Total assets of the Hawker Siddeley—Blackburn—de Havilland group in the United Kingdom stand at over £70 million, and the combined business will form the largest aircraft manufacturing group in the British Commonwealth. In ad-

The first three Avro 748s in production. This short-to-medium-haul feeder-liner (two Rolls-Royce *Dart* turboprops) is also to be manufactured under licence in India.

Three Rear-Mounted Jets... the Airco DH.121



The Airco DH.121 short-haul airliner. British European Airways has ordered 24, and deliveries are due to begin in 1963 or earlier.

Britain's aircraft industry can today offer airlines four new designs for short and medium haul operations: the Airco DH.121, Vickers VC.11, Bristol 205 and Hunting 107. So far, however, the only model for which orders have been received is the DH.121, of which British European Airways has ordered 24 (with an option on another twelve). A first DH.121 is scheduled to be ready for flight testing by the end of 1961, and BEA can expect to receive its first six aircraft not later than 1963.

The Airco DH.121, a typical short-haul model which has repeatedly been described as a *Viscount* or *Metropolitan* replacement, is designed to carry some 80 passengers and to be capable of operating from 6,000-ft runways. Maximum speed can be estimated at around 530 knots, and economical cruising speed at 510 knots. Profitable stage lengths range from 200 to more than 1,000 nautical miles.

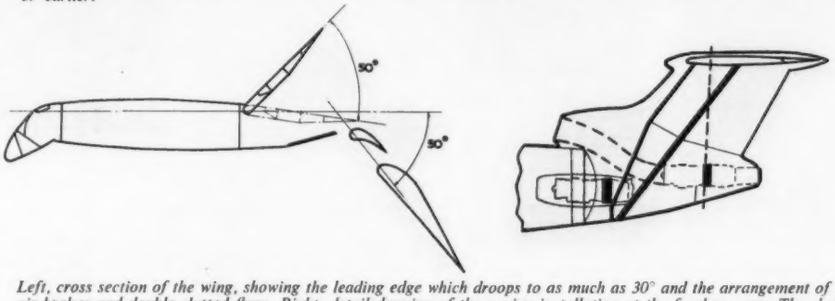
After extensive studies, a three-engine layout was chosen (Rolls-Royce RB.163 by-pass jets of 10,100 lb thrust each). The decision was mainly for reasons of economy, but the case for three engines is closely connected with the particular design requirements of the aircraft. While the cruising thrust needed does not vary substantially over varying stage lengths, the required take-off thrust increases considerably with stage length (because of increased weight), particularly if the ability to operate from 6,000-ft runways is to be maintained. To provide adequate thrust for take-off—with due allowance for the engine-out case—a twin-engine layout would be over-powered for cruise. Four engines, on the other hand, would be unnecessarily expensive in first cost, maintenance, etc. All in all, for an aircraft of the size, weight and performance specifications of the DH.121, three RB.163s were found to give the best relationship between cruising thrust and take-off thrust.

The choice of engine number then led more or less automatically to the rear-mounted layout, and this brought other welcome advantages, such as clean, uncluttered wing design with full-span flaps, low trim corrections in the event of one engine failure, elimination of danger to aircraft structure or passengers in the event of compressor or turbine blade rupture and, last but not least, a low noise level in the passenger cabin.

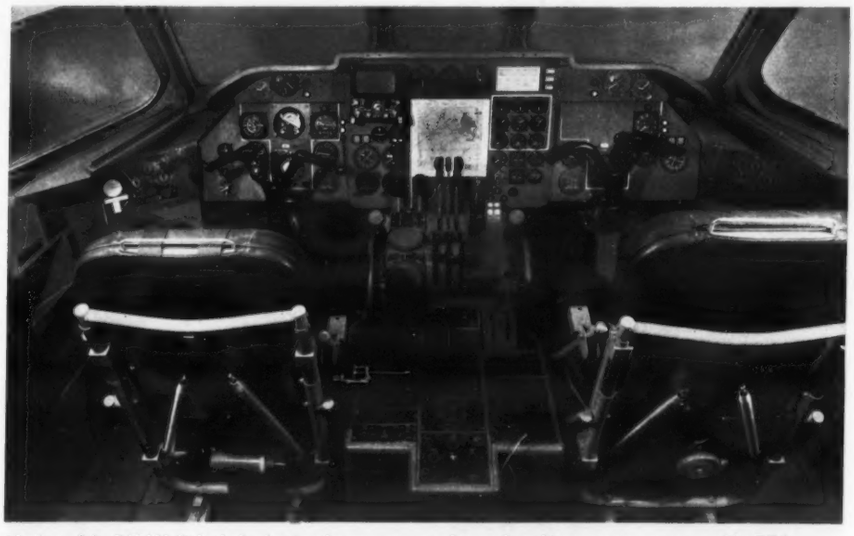
It is interesting to note here that Sud-Aviation's initiative in mounting the engines at the rear in the *Caravelle* is now being followed throughout the world. Three American manufacturers, for example, have also chosen this configuration for new medium-haul designs.

A three-engine layout and rear mounting are not the only characteristic features of the DH.121. From the beginning of the design work it was planned eventually to fit a fully automatic landing system to be developed jointly by Smiths and Elliott. However, as it will be some years before the new Autoland system is operational, the DH.121s to be delivered around 1963 will initially be equipped with an Autoflare system, which will ensure automatic flare-out before touch-down. The experience gathered with this installation will then be utilized in later development work and will ultimately lead to the fully automatic landing system. Full all-weather operation with the Autoland system is expected for about 1970.

Main data for the DH.121 are as follows: Span 89 ft 10 in.; length 104 ft; wing area 1,350 sq.ft.; angle of sweep 35° at 25% of chord; freight and luggage hold 620 cu.ft.; max. gross weight 105,000 lb; max. landing weight 100,000 lb; max. payload 21,500 lb; max. speed 530 knots; economical cruising speed 510 knots at 32,000 ft; range roughly 1,000 to 1,100 nautical miles.

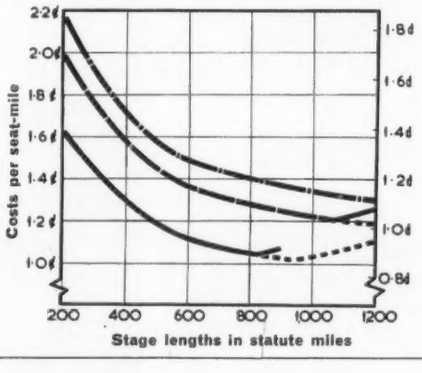


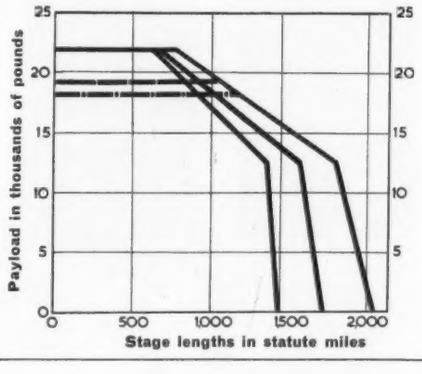
Left, cross section of the wing, showing the leading edge which droops to as much as 30° and the arrangement of the air brakes and double slotted flaps. Right, detail drawing of the engine installation at the fuselage rear. The sketch reveals that, even in the event of rupture of compressor or turbine blades, the load-bearing structure is unlikely to be endangered. All three Rolls-Royce RB.163 jets can be fitted with silencers, at the customer's request. Thrust reversers are fitted only to the two outboard engines.



Mockup of the DH.121 flight deck, showing the arrangement of controls and instruments, as requested by BEA.

The diagram on the left below illustrates the direct operating costs for the DH.121 calculated by the ATA method. The lowest curve relates to the version with cabin accommodation for 100 economy class passengers, the centre curve to the layout for 83 passengers in mixed-class operation, and the top curve to the model for 76 passengers (also mixed-class). Right: *Payload/range diagram for the Airco DH.121, for the same three models (100, 83 and 76 passengers). The right-hand limit curve is for long-range cruise, the centre curve for most economical cruise, and the left-hand for high-speed cruise.*





dition, Hawker Siddeley and de Havilland have substantial interests in Canada (A.V. Roe Canada Ltd. and its subsidiaries on the one hand, and The de Havilland Aircraft of Canada Ltd. on the other), in Australia and New Zealand, and in South Africa (in the case of de Havilland).

The English Electric — Vickers — Bristol group

The second major airframe group is being formed by different methods, although the final result from the development and production points of view will doubtless be much the same. Instead of one established group absorbing other enterprises, three large parent companies—English Electric Co., Vickers Ltd. and Bristol Aeroplane—have decided to transfer their aircraft and missile subsidiaries, English Electric Aviation, Vickers-Armstrongs (Aircraft) and Bristol Aircraft, to a new holding company. Forty percent of the shares in this company will be held by English Electric and Vickers each, with the remaining 20 percent going to Bristol Aeroplane. Policy will be controlled by the Board of the new company, whose members will include directors from the three principal companies and the three subsidiaries, while financial responsibility for aircraft and missiles already in production will remain with the present manufacturers. All subsidiaries will retain their own names and identities. Hunting Aircraft has also been invited to join this group.

The parent English Electric Co. is an old-established concern with vast ramifications throughout the electrical industry: domestic appliances, industrial electrical equipment, locomotive equipment, power generating equipment, etc. Total assets at the end of 1959 were £80 million.

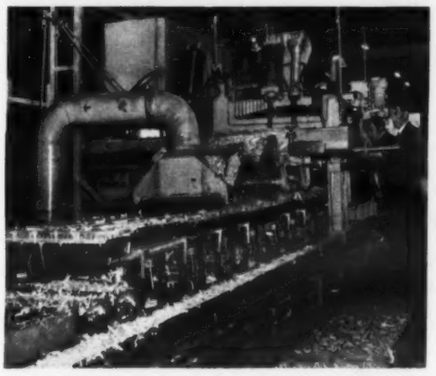
The Vickers Ltd. industrial empire spreads even further: ship-building, steel, naval ordnance, tractors and earth-moving equipment, railway coaches, optical instruments, computers, simulators, training and research reactors, and many other fields. Net assets of the group at the end of 1958 were £111.4 million.

Bristol Aeroplane Company, in addition to its Bristol Aircraft subsidiary, also owns a half share in Bristol Siddeley Engines (formed early last year in conjunction with Armstrong Siddeley Motors, up till then a full member of the Hawker Siddeley Group) and a 15¼ percent interest in Short Brothers & Harland. Non-aeronautical activites are confined to the manufacture of high-performance cars.

The helicopter group

Side by side with the growth of the two above-mentioned giants, a single helicopter manufacturing group has also been emerging. The first move in this direction came in July last year, when Westland Aircraft took over the helicopter operations of Saunders-Roe, and has now been followed by an agreement to assume responsibility for the helicopter department of Bristol Aircraft and by acquisition of Fairey Aviation. Westland thus becomes by far the largest helicopter manufacturer in Europe. The company's programme covers helicopters of all sizes and for all applications, civil and military, ranging from the 2,200-lb Saunders-Roe *Skeeter* to the 36,000-lb Westland *Westminster* and the 50,000-lb Fairey *Rotodyne* (plus the Fairey *Gannet* anti-submarine aircraft and Fairey's share in the DH.121 production).

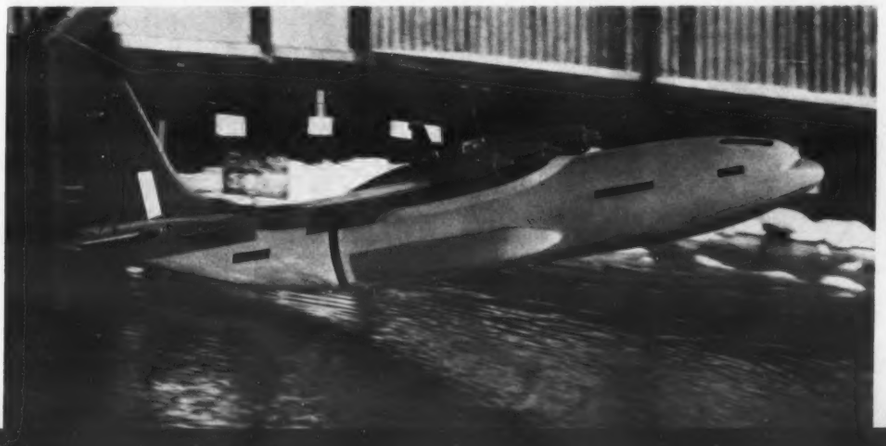
Modern manufacturing equipment. Above, a Hufford stretch-wrap press at English Electric's Preston plant. Below right, an 8,000-ton rubber press (English Electric); below left, a profiling machine milling out integral stiffeners in a Vickers *Vanguard* wing panel.



The "Big Two's" Work Programme

	Current production		Missiles	Prototypes, research aircraft and known projects
	Civil aircraft	Military aircraft		
Hawker Siddeley Group				
Armstrong Whitworth	Argosy	AW.660, Seahawk	Seaslug	STOL Argosy
A. V. Roe	Avro 748	Vulcan B.2	Blue Steel	—
Folland Aircraft	—	Gnat Gnat Trainer	—	Mach 2 Gnat
Gloster Aircraft	—	Javelin	—	—
Hawker Aircraft	—	Hunter Hunter Trainer	—	P.1127
Blackburn Aircraft	—	NA.39	—	—
de Havilland Aircraft	Comet 4 Airco DH.121 Dove & Heron	Sea Vixen	Blue Streak Firestreak Red Top	DH.121 Mk.2
HSG Advanced Projects Group	—	—	—	Supersonic airliner
English Electric-Vickers-Bristol Group				
English Electric	—	Lightning 50% TSR.2	Thunderbird Blue Water	Supersonic airliner, civil VTOL
Vickers Armstrongs	Viscount Vanguard VC.10	50% TSR.2 Scimitar	Vigilant	Swallow Super VC.10 VC.11
Bristol Aircraft	Britannia	Britannia	Bloodhound	T.188 (research), Type 205 (civil) Plastic light aircraft
Hunting Aircraft	—	Jet Provost Pembroke	—	Jet flap research vehicle Type 107 (civil)

A 1/18 scale model of the Short *Britannic* military transport undergoing ditching tests. The final design has the engine nacelles slung beneath the wings.



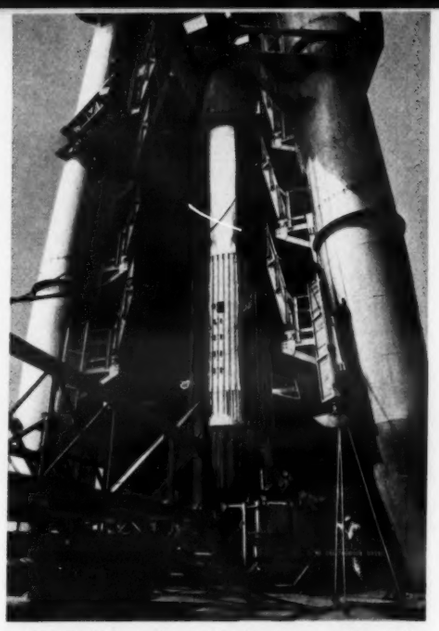
The "independents"

Still standing aloof as stalwart individualists—for the time being at any rate—are Handley Page and Short Brothers & Harland. Handley Page has the *Victor* V-bomber still in production, is working on a small order for the *Dart Herald* for the Ministry of Supply and on the H.P. 113 research transport and the H.P.115 supersonic research vehicle. Short has a contract for the S.C.5 *Britannic* military transport and for the *Seacat* navy missile, and is doing experimental work on both civil and military VTOL based on the principles of the S.C.1.

What the future of these two companies will be is not clear at the present time. Will they succeed in remaining independent? Or will they likewise find it expedient to yield to the Ministry of Aviation's pressure and join one or other of the big groups? Of the two, Handley Page appears to be most dependent on aeronautical products, so might perhaps feel the outlook somewhat bleak outside the shelter of more powerful concerns. Short Brothers is reasonably well occupied at the moment, not only on its own designs, but also on subcontracts for the Bristol *Britannia* and the English Electric *Canberra*. Moreover, this company presents a somewhat thorny problem in any rationalization programme, since–apart from the small Bristol holding mentioned earlier and a similar holding by Harland & Wolff, the shipbuilders–it is Government-owned.

The engine picture

So far, at any rate, nothing is known of any regrouping plans for the actual aero engine manufacturers, although they too are included in the Government rationalization scheme. Rolls-Royce, with its firmly established position both in and outside the aeronautical field, is unlikely to be interested in amalgamating with anyone else.



De Havilland Propellers Ltd. is the design authority for the *Blue Streak*, Britain's long-range ballistic missile.

Alvis too, though it remains solidly devoted to piston engines, has other sources of income in motor cars, armoured vehicles, etc. D. Napier & Son, though associated with English Electric, is not affected by the formation of the new airframe group. Finally, both the Blackburn and the de Havilland engine companies are going to the Hawker Siddeley Group, along with their parent companies. Will they continue as more or less independent subsidiaries of the Group, or will one or the other of them find its way into Bristol Siddeley Engines? At the pace of recent developments, the answer may perhaps not be long in coming*.

* Developments since this article was written are outlined in the yellow pages of this issue.

Looking ahead

So far so good. Manufacturers are obediently burying old rivalries and forming themselves into a streamlined industry. But nobody would be so rash as to assert that all cause for concern has now been magically removed. No amount of regrouping will, of itself, solve either the immediate or the more distant problems.

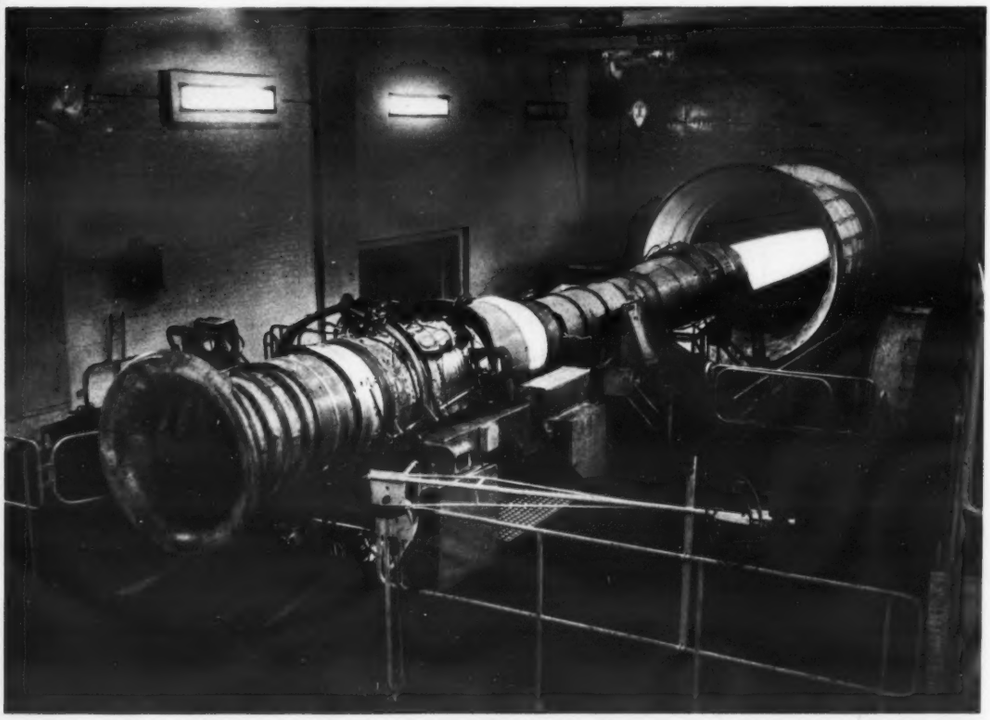
Many of the aircraft now in production must be classed as "older generation" (the *Canberra*, for example, has been in production for ten years, and the *Viscount*, *Seahawk* and *Gannet* for eight). They have made good money in their time but must be expected, in the normal course of events, to be phased out within the next year or two. So far none of the new models now going into production have been ordered in numbers likely to bring in much hard cash from the export market. It is going to take a lot of hard work from the sales staff—and perhaps a little more Government assistance in the form of export credits?—to avoid the next few years finding the industry in one of the trickiest positions it has known for a long time.

Looking ahead. Dr. Barnes Wallis demonstrates his *Swallow* variable-sweep supersonic design, in which Vickers is interested.

Another problem concerning the more immediate future is the actual size of the industry. Recent official and unofficial statements all agree that a labour force of 240,000 is just too big, that the most the potential markets can be expected to support is 150,000, the pre-Korean level. How are 90,000 redundant skilled workers to be absorbed elsewhere in the economy without upheaval? This is another question to which rationalization provides no automatic answer.

However, when we look to the more distant future, prospects seem a good deal brighter. Designers have any number of projects in hand (most of them still very much on the secret list); the new groups will be immeasurably stronger from the financial point of view, they have the know-how, the research laboratories and the manufacturing facilities to produce successful aircraft, and will be able to distribute work more rationally among their—no longer rival—subsidiaries; and finally the Government has promised that support will be forthcoming for research and development of civil aircraft and engines. Given realistic planning and careful market research, there seems no reason why Britain should not maintain or even strengthen her position on the world market for aeronautical products. ←

The Bristol-Siddeley *Olympus* (type-tested at 17,000 lb thrust) on the test bed. An advanced version has been specified for the TSR.2 tactical strike/reconnaissance aircraft.



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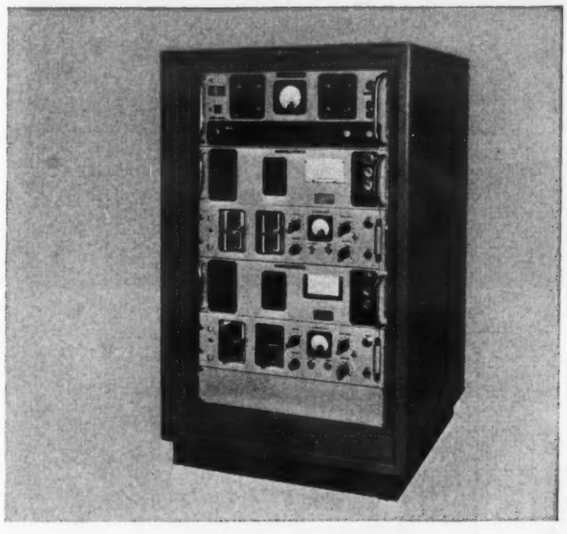

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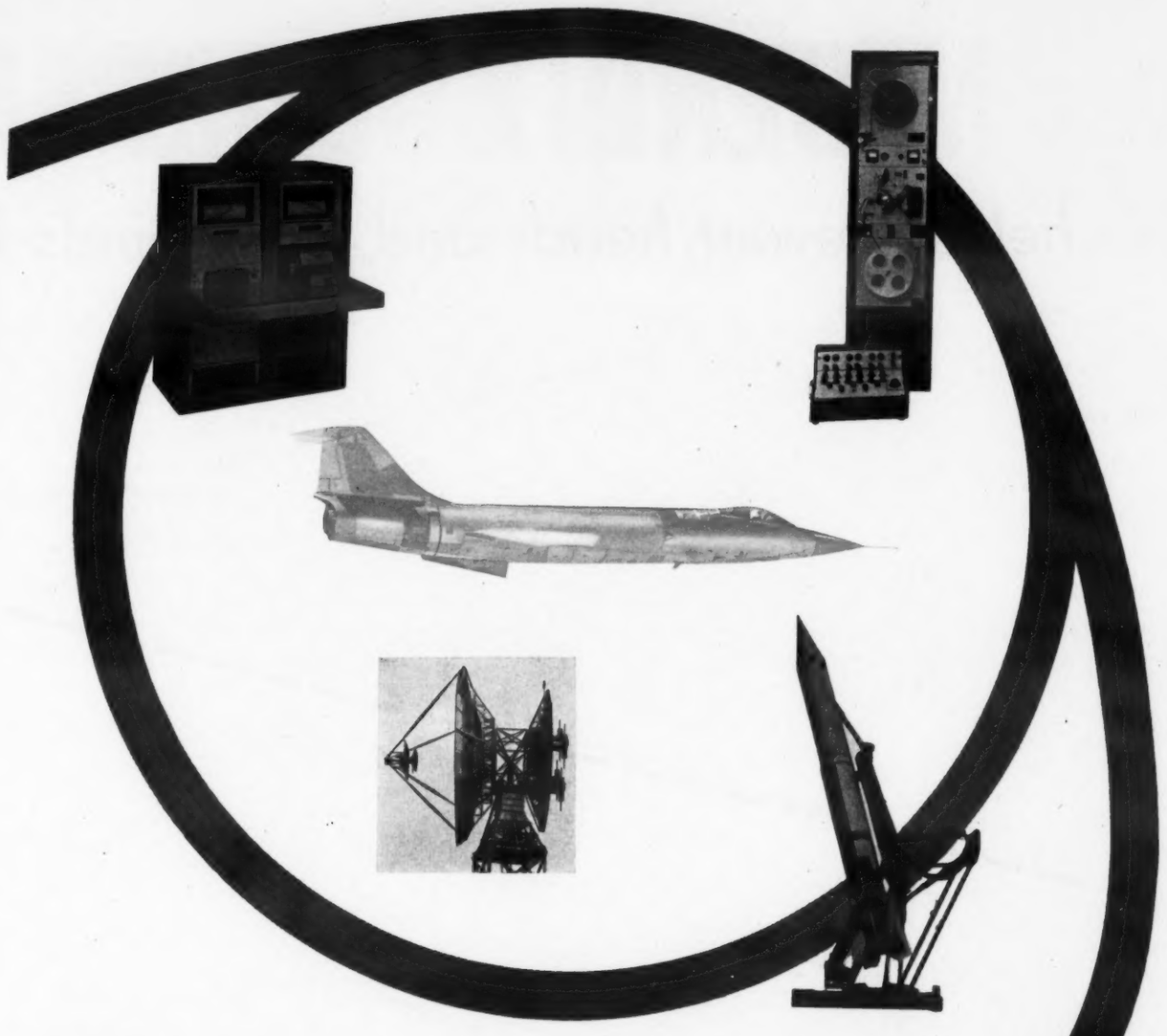

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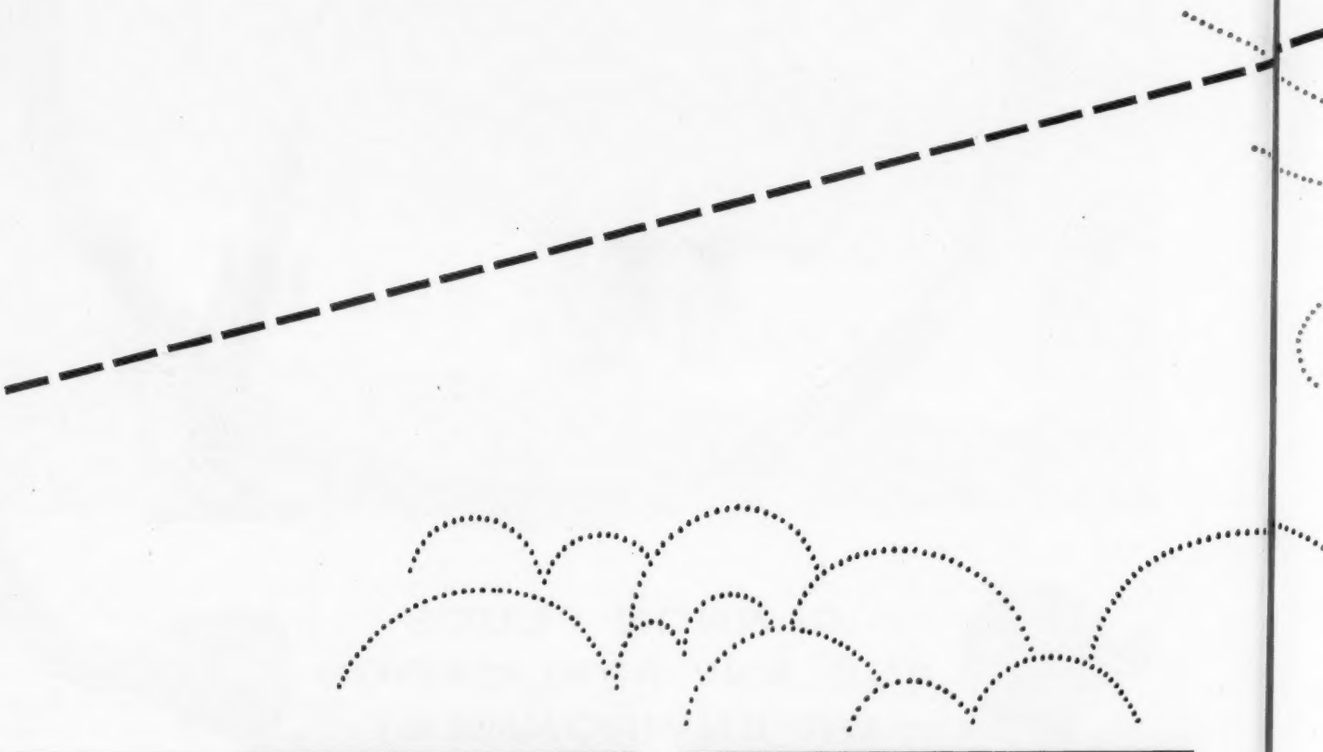

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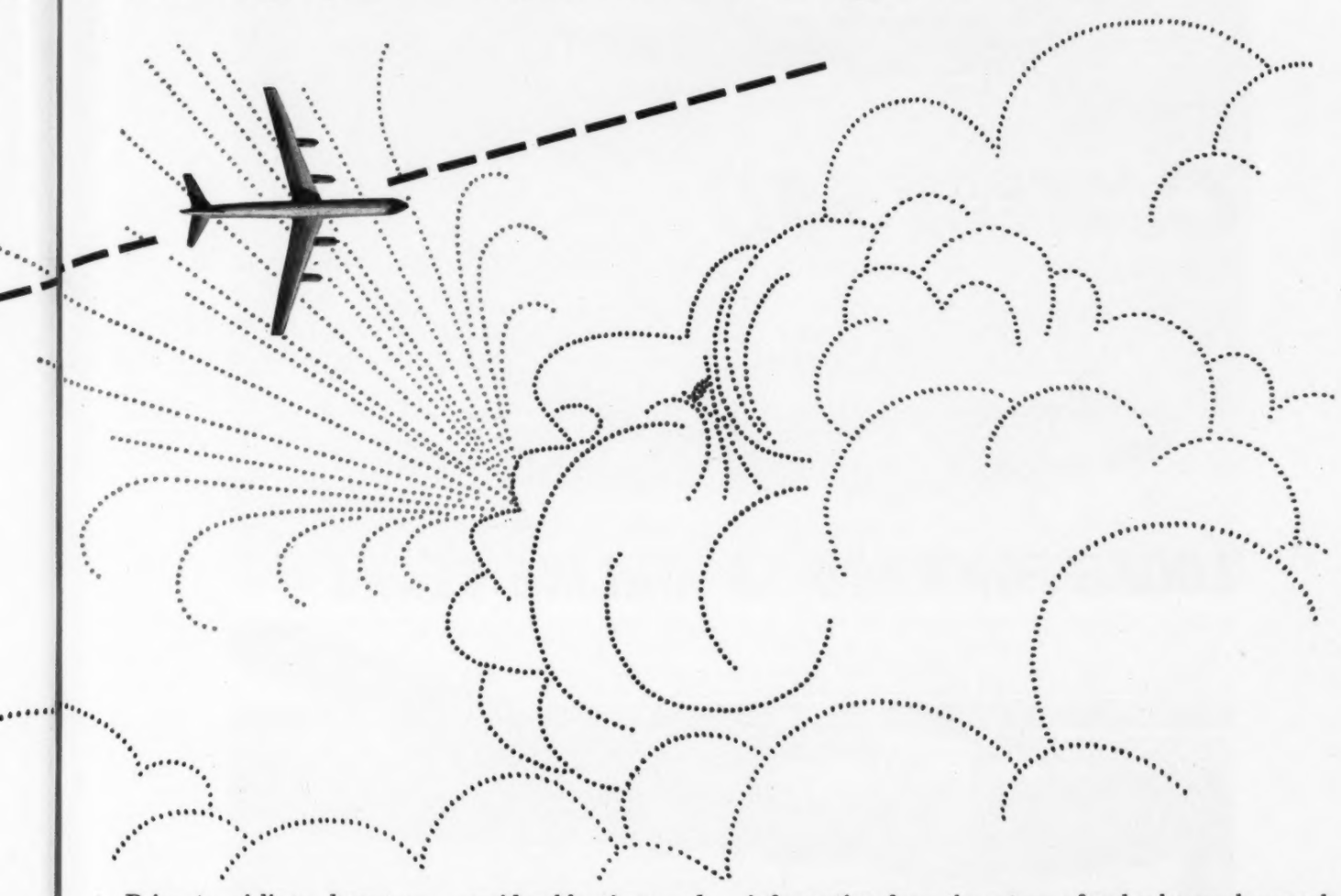

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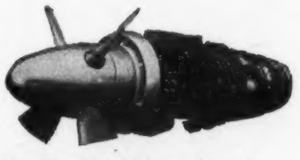

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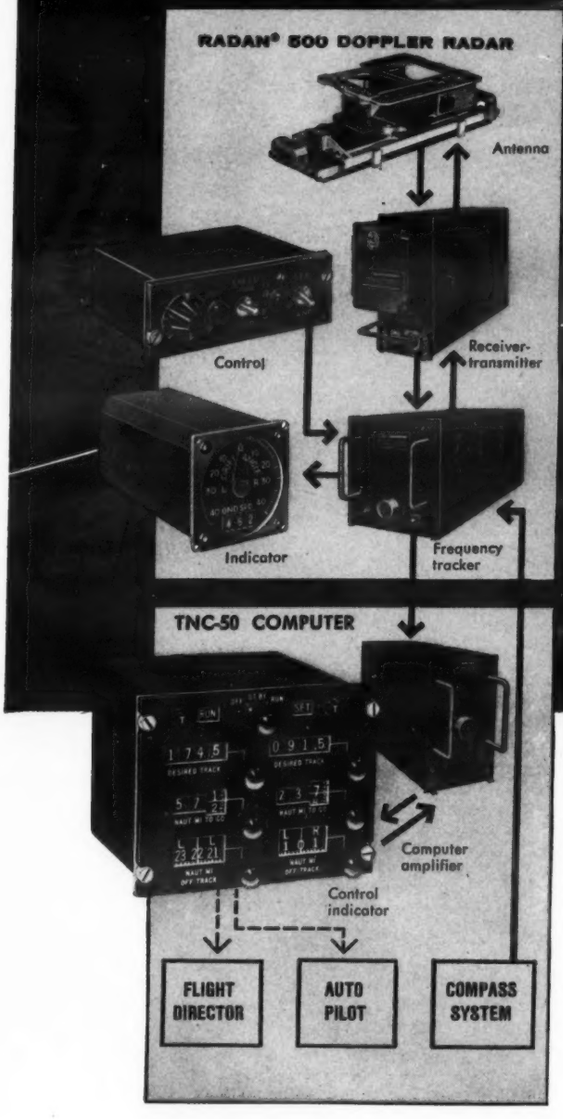

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RELIABILITY: Thirteen years of direct Doppler experience, service feedback on more than 1,500 operational GPL Doppler systems, continuous product improvement programs, and the special requirements of airlines dictated RADAN 500 and TNC-50 design. The result: reliability, ease of maintenance, and maximum time between overhaul.

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IMPROVE YOUR TRAINING WITH SAAB BT 13 HIT INDICATOR

With earlier gunnery training systems it was difficult to obtain reliable and rapid scoring reports when firing at towed targets or from aircraft at ground targets. It was not possible to count the number of direct hits on the target while shooting was in progress, and much valuable time had to be wasted on scoring and change of targets.

The SAAB BT 13 Hit Indicator — now in use in the military services of many countries — eliminates these drawbacks and creates a quicker, cheaper and more efficient means of training gunners. With the SAAB BT 13 the gunner gets immediate information of his results.

The SAAB BT 13 is based on an acoustic-electronic method of recording the shock wave around a projectile.

A microphone in the target picks up the shock wave from all projectiles within a certain region. Signals from the microphone travel via an electric cable — which also serves as the towing cable — to a recorder containing an amplifier and a counter. When practising against towed targets the recorder is placed in the towing aircraft, where the hits can be counted and reported to the gunner by radio.

Gunner immediately informed of his results

Sighting can be adjusted between attack runs

Size of target zone can be varied according to gunner's skill

Target need not be changed between gunners

Shortened training periods

Equipment can be used for air-to-air, air-to-ground or ground-to-air firing

Can be used for ordinary wing targets and drogues

Equipment easily installed in any towing aircraft

Suitable for 13 to 105 mm ammunition

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AVRO 748 AVRO 748 AVRO 748 AVRO 748 AVRO 748 AVRO 748

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Single Seat Combat Aircraft

By Interavia Study Group

1. Attack is the Best Form of Defence

European military experts and engineers have one immediate problem in common: how to adapt for an offensive role a class of aircraft originally designed and built for air defence rather than for the attack of ground targets. The problem has arisen as a result of the revolutionary changes in strategy brought about by atomic weapons in the first place and later by ballistic missiles. *Military thinking has thus passed through three distinct stages in less than a decade.*

• The first stage

Within its own modest scope, *Interavia* also contributed to the first stage. When the European air forces began to receive American combat aircraft under the Mutual Defense Assistance Program, their staffs found that though these first-rate machines generally had a long range, their rate of climb was not sufficiently good for European conditions. These aircraft were admirably equipped, but relatively heavy and hence costly. European countries wishing to produce their own interceptors could not follow this example. Europe's geographical situation, the state of its industry and its limited resources dictated a different approach. It was at this time that *Interavia* pleaded the cause of the light *interceptor,* with simple equipment, cheap to produce but with a sufficiently high rate of climb to meet a threat emanating from an area within a close geographical range.

But there are no miracles in engineering. If the interceptors of this new family of aircraft could not carry with them the electronic equipment they required to detect their air targets or place themselves in position for firing, then this equipment had to be put somewhere else. At the time when the first light interceptors were designed, it was thought that detection and guidance aids could be installed on the ground and that the interceptor could be guided, like a missile, from the ground (as was done for example during World War II, with the GCI = Ground Controlled Interception system).

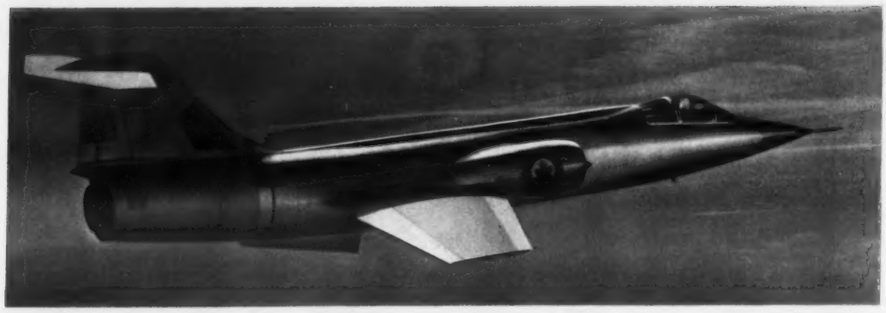
The formula led to a number of remarkable aircraft, such as France's *Trident, Mirage I* and *Durandal,* Britain's *Gnat* and Italy's *Sagittario.*

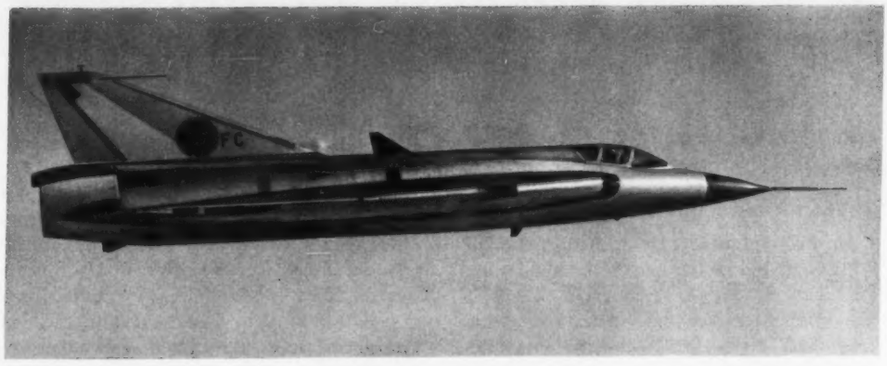
• The second stage

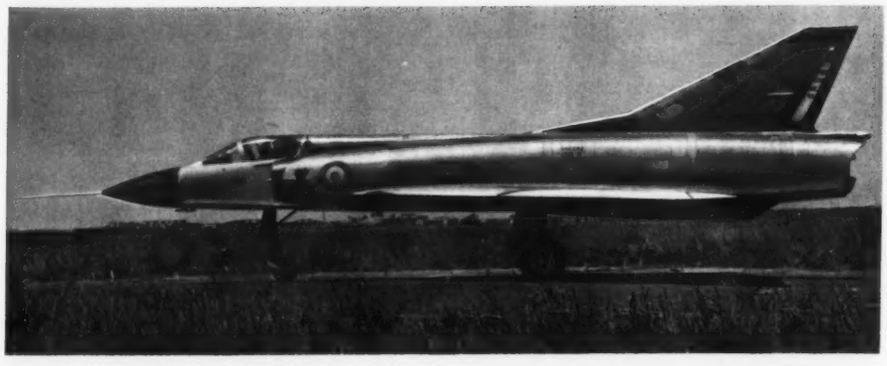
Hardly had the prototypes of these aircraft come out of the workshops than a new strategic concept rendered them useless, at any rate in the European theatre for which they had been designed. Up until 1953 NATO's inter-Allied command hoped to be able to assemble the strength for a defensive policy founded essentially on the use of conventional forces alone. When, after the Lisbon meeting, the European members of NATO had turned out their pockets and the United States had announced that it could not increase the aid it was already giving, General Ridgeway and his successor General Gruenther were forced to look for a substitute for the some hundred divisions it had been hoped to establish. This substitute was nuclear armament. But the moment the free world announced—through Field Marshal Montgomery—that any form of aggression would be met by nuclear weapons, this meant the end of conventional warfare in Europe.

First stage: Light interceptor with a minimum of equipment and light weapons, illustrated by the Folland *Gnat Mk.1* (with Bristol Siddeley *Orpheus 701* jet).

Second stage: English Electric P.1B *Lightning F.Mk.1* heavy single-seat interceptor (two Rolls-Royce *Avon RA.24Rs* with reheat). The aircraft carries extensive electronic equipment for all-weather operation and is armed with 30-mm cannon and air-to-air missiles.







Third stage: Conversion of single-seat fighters for offensive missions and all-weather operation. Three striking examples (from top to bottom): 1. Drawing of the Canadian Lockheed CF-104 *Starfighter* (similar to the West European F-104G and with General Electric J79-GE.7 jet plus reheat and North American NASARR fire control system); 2. Saab J35 *Draken* (with Svenska Flygmotor *Avon RM6B* plus reheat and Ferranti *Airpass* fire control system); 3. Dassault *Mirage IIIA* (with SNECMA *Atar 9* plus reheat and SEPR 841 rocket engine, and Ferranti *Airpass* fire control system).

Henceforth there could only be either peace and the *status quo*, or atomic war with its frightening toll of destruction.

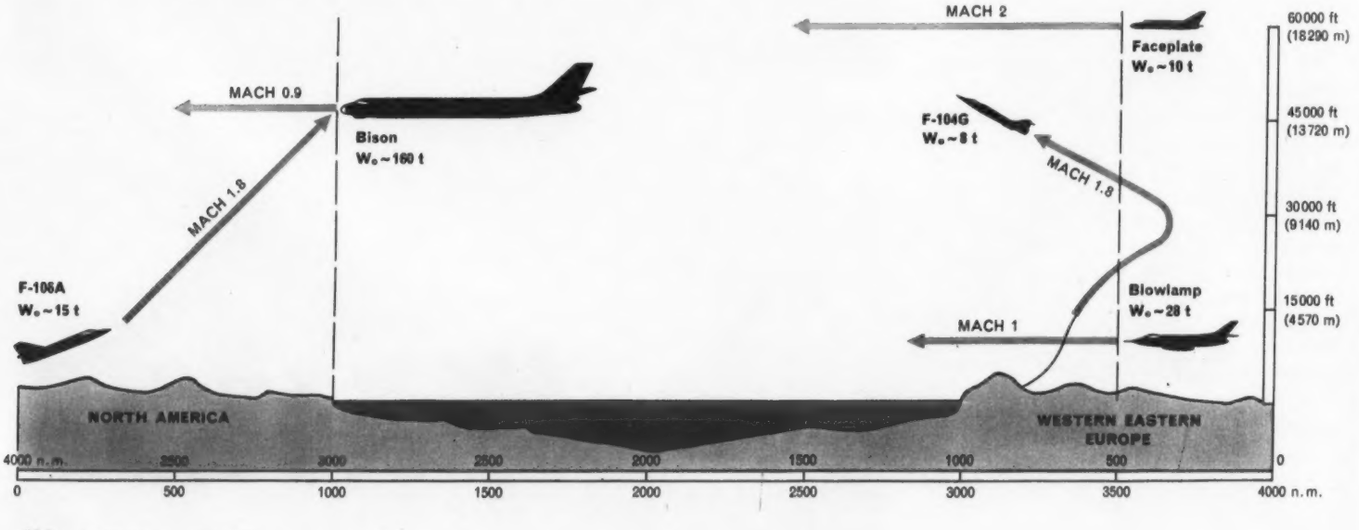
The decision to rely on nuclear weapons had at least two repercussions on aerial strategy:

1. *Defence lost much of its value, at any rate in Europe.* Of what use was it to intercept even a high percentage of a raiding force, if the few aircraft that got through could still cause tremendous damage?

2. If an air defence organization still had the advantage of complicating the adversary's task—though it could not stop enemy raids—its interceptors *should not be dependent on fixed ground guidance systems which would be highly vulnerable to attack.* If there still was a solution to the air defence problem, it was to be found only in mobility, and hence in the relative invulnerability of the aircraft itself. The obvious answer was to install complete electronic equipment in the actual aircraft, thus reducing the interceptor's dependence on vulnerable ground systems.

This inevitably led to an increase in the fighter's size, weight, power and finally cost. Europe's military theorists had to revise their ideas, and the air forces to abandon the *Trident, Gnat* and other light models. The *Mirage III* succeeded the *Mirage I,* and the English Electric P.1B came into its own.

Diagram I: "Catch as catch can" over Western Europe and North America.
Shown here are the two continents separated by roughly 2,000 nautical miles of Arctic Ocean or North Atlantic, and the weapons systems available today for the offensive and defensive drawn to the same scale, with max. speed (distance covered per hour) and altitude.
Because a medium supersonic fighter-bomber weighing "only" some 20,000 lb on take-off (for a radius of action of 500+ nautical miles) can carry atomic or hydrogen bombs of the same destructive power as a large subsonic jet bomber with global range weighing sixteen times as much, and because the size, altitude and speed of the attacker thus depend primarily on the distance to the target, the prospects of successful air defence by means of manned aircraft in the areas close to the front are slender, although they can still be termed good in more distant areas. The diagram obviously also holds good for the opposite direction (i. e., attacks from West to East).



At the same period it was realized that a new mission could be performed, consisting in flying *below* the radar coverage at any rate on brief penetrations into the enemy's airspace. Aircraft for this task would necessarily have a short range because of their heavy fuel consumption at low altitudes, and would therefore have to be stationed near the front line. Hence they would have little chance of escaping destruction on their bases unless they could use any short strip for take-off and landing or could constantly change bases. The Fiat G.91 was born of this requirement —offensive missions at tree-top level and virtually permanent mobility. The programme under which the G.91 was built was the first sign of a shift in emphasis towards the offensive role and was prepared early in 1954, soon after the decision to use mass destruction

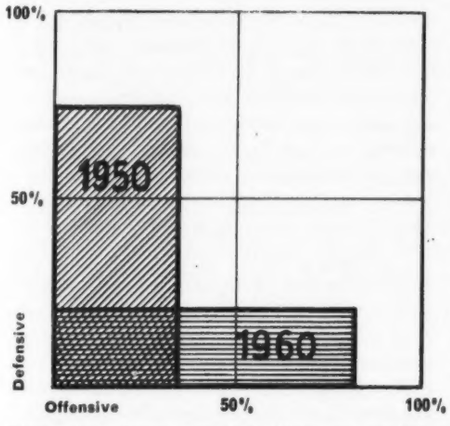


Diagram II: Whereas yesterday's fighter was required to perform some 75 percent of its missions as an interceptor (defensive) and only 25 percent as a fighter-bomber and strike aircraft (offensive), today something like 80 percent of all missions must be offensive.

weapons in Europe as an answer to aggression.

• The third stage

Just as the European aircraft industries had abandoned the light fighter configuration and embarked on the medium interceptor programme, at the same time tackling the technological developments needed for low-level strike missions, a third basic switch in strategy forced them once again to reorientate their efforts. This switch resulted from a scientific achievement going back to 1951 and 1952, *namely the miniaturization of nuclear warheads.*

1. Once a tremendous force of destruction could be housed within a projectile of small size and low weight, the "bomber" was no longer at a disadvantage vis-à-vis the interceptor, except as regards the weight and volume of the fuel it carried. That is to say, its vulnerability became more or less dependent on its range. The latest models of Soviet fighters, taking off from close to the Iron Curtain, could now carry an atomic bomb load as far as and beyond the Rhine, and this

Designed from the outset for fighter-bomber and strike missions under instrument flight conditions: the Republic F-105 *Thunderchief*. Powered by one Pratt & Whitney J75 plus reheat, this aircraft carries its entire A or H bomb load inside its fuselage bay. If it is also armed with air-to-air missiles—in addition to its 20-mm General Electric M-61 cannon, it can be used for air interdiction missions above the battlefield or for interception over its own home territory.

bomb load would probably be very little bulkier and certainly less weighty than the armament carried by the fighter designed to intercept it. Over such short distances it became impossible to put an interceptor into operation, even if it had the best possible electronic equipment aboard. Admittedly, interception on a head-on collision course was still possible, since theoretically at least this method enabled an interceptor to attack a target flying at a higher speed than its own. But the airborne radar equipment was inadequate in range to meet the requirements of a head-on collision course manoeuvre against very fast aircraft. Above all it was essential that the defences should not be taken by surprise and that the interceptors should be in the correct position for launching their air-to-air missiles. *Finally, analysis showed that batteries of surface-to-air missiles would be far more efficient than the combination of interceptor and air-to-air missiles.*

In the United States the situation was somewhat different. In order to reach the shores of the New World, Soviet bombers would have to haul a heavy load of fuel and hence cruise at subsonic speeds. The interceptor thus retained its margin of superiority over such necessarily slow machines, and an air defence organization which had ceased to be of value in Europe still preserved, provisionally at least, a certain utility in the United States.

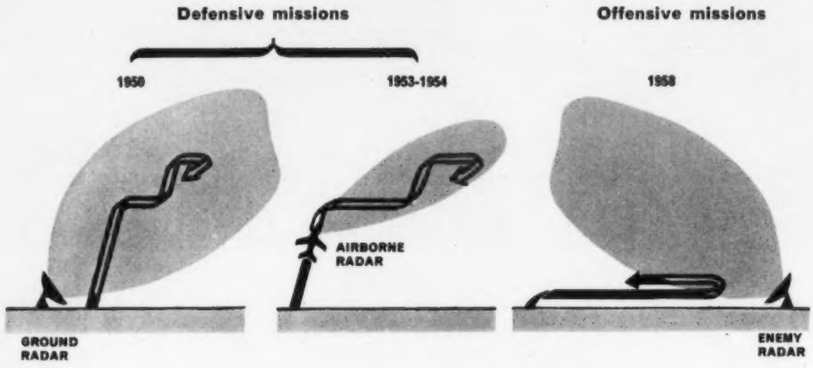
Diagram I illustrates the varying relationship between the fighter and the bomber as the distance between base and target increases. Since speed performance is, to a certain extent, dependent on the weight of the aircraft in question, it is clearly visible that the American fighter will still have a margin of superiority over the Soviet bomber, but that this advantage disappears when the Soviet "bomber" is a fighter-bomber with sufficient range to attack targets in Western Europe.

This explains the value still attached to the F-106, for example, despite the development of missiles such as the *Bomarc*. As long as there is any possibility of attack by manned bombers, whether subsonic or supersonic, it will be necessary to go out and reconnoitre all unidentified aircraft crossing the skies of North America. But in Europe, with its lack of territorial depth, it looks as if this identification task would be impossible.

2. Immediately on the heels of the above transformation came a second technical feat, which was once again to dictate a revision of strategic concepts and shake the famous principles of war to their very foundations. This revolution resulted from the *marriage of the miniaturized nuclear warhead and the ballistic missile as carrier*. With this combina-

In areas well behind the front line the prospects of successfully operating supersonic interceptors with all-weather equipment are still good. Thus the Convair F-106A *Delta Dart* (Pratt & Whitney J75 plus reheat) is still one of the mainstays of the USAF's Air Defense Command and hence of the North American Air Defense Command (Norad).

New Specifications for Single-Seat Combat Aircraft



1950: Light interceptor with short radius of action and a minimum of equipment; almost entirely dependent on ground radar and control.

1953: Medium interceptor with longer radius of action and improved equipment, in particular airborne radar; less dependent on ground control.

1958: Offensive aircraft with good penetration range, equipped to underfly the enemy radar coverage and to attack ground targets by LABS methods.

Substantial modifications are necessary to convert an aircraft from a defensive to an offensive role. The table below compares the operational requirements and conditions for both roles.

Defensive	Offensive
• The target is airborne, moving at high speed, but is usually clearly distinguishable against a background of sky.	• The target is on the ground. It is either static or moving slowly with respect to the aircraft, but is difficult to distinguish.
• A combination of ground and airborne radar and self-guided air-to-air missiles is necessary if the interception is to be successful and the enemy destroyed. Ground installations play an active part.	• The offensive aircraft must have its own navigation system, particularly at low altitudes, and, if possible, electronic equipment for locating and attacking a ground target in poor visibility. Here the part played by ground installations is passive. The aircraft must be able to operate in all weathers using its own airborne aids; it must be independent of ground installations, except for taking bearings (e. g. TACAN) or controlled approach (AILAS = Automatic Instrument Landing Approach System; AGCA = Automatic Ground Controlled Approach).
• The interceptor must be able to fly at high altitudes and high Mach numbers. At the present stage of technical development the problem of frictional heating can be solved at present operational speeds, i. e., around Mach 2.	• Flying at low altitude, the fighter-bomber will never exceed transonic speed. But, since it operates in a dense atmosphere, designers are faced with cooling problems. Structure and skin must be specially designed to withstand low-altitude stresses (turbulence, tight turns etc.).
• A certain degree of endurance simplifies interception missions and enables ground radars to be exploited to the full. But this is not the primary requirement of the interceptor, particularly in Europe, where distances are short.	• The low-altitude radius of action becomes vitally important, as it extends the aircraft's offensive scope, while not reducing the relative invulnerability of the fighter-bomber which must seek to escape detection and destruction by surface-to-air missiles, by moving near the ground at more than 600 knots.
• The interceptor's weapons are relatively simple: air-to-air guided missiles with infra-red or active or semi-active radar homing head.	• The offensive aircraft's weapons must be more diversified to suit a wide variety of targets. It must be able to carry under its fuselage and wings air-to-surface missiles, TNT or atomic bombs and rockets, and also be equipped with rapid-fire cannon.

For both types of aircraft the ability to use short runways and makeshift landing-strips would be added operational advantages. The fighter-bomber, which is less confined to a specific zone than the interceptor, must be able to make do with the minimum ground organization and should be fitted with low-pressure tyres and braking equipment for landing, such as parachute or arrester hook.

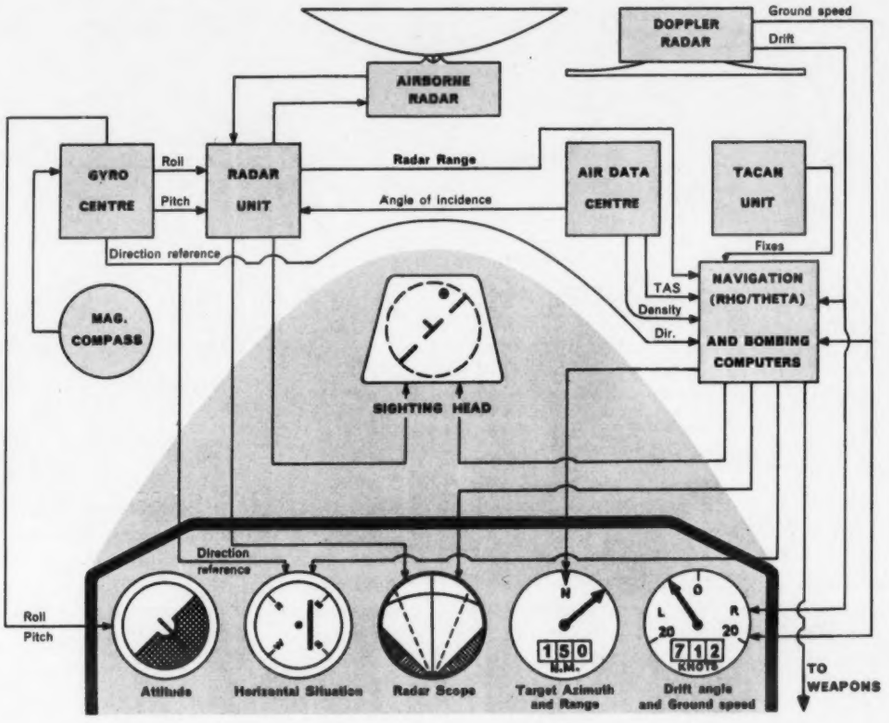
tion, there will no longer be any need of subsonic bombers or supersonic fighter-bombers to wipe a country off the face of the map by destroying its political, social, industrial and economic structure. A few hundred, or even a few tens of hydrogen-warhead missiles will suffice. Not even the best of interceptors, stuffed full of electronics, will be able to prevent weapons of this kind from falling.

This strategic revolution was foreshadowed by Mr. Khrushchev when he announced, in August 1957, the Russians' first successful tests with intercontinental ballistic missiles. This time, the value of an air defence system became more problematical still, at any rate until such time as efficient anti-missile missiles become operationally available. Since there is no known method of parrying this kind of attack, the only solution was to *threaten to retaliate by the same means*. Defence through the threat of reprisals remained the sole resource of a strategy which was nevertheless fundamentally defensive. Air force staffs, assisted by their engineers, were obliged to pursue to its furthest limits the reasoning outlined the moment nuclear weapons were introduced into the Great Powers' arsenals, and to give first priority to weapons designed for offensive operations.

In the aviation sector this meant concentrating efforts on the ballistic missile and on the offensive aircraft capable of escaping the initial blow and of penetrating the enemy's defences at high speed or low altitude. Aircraft under development had to be directed towards the attack role, and existing aircraft—or those that were not already fighter-bombers—had to be converted to meet offensive operational requirements. The *Mirage III* interceptor, for example, was followed by a *Mirage III* fighter-bomber, and the original Lockheed F-104, which was essentially designed for point defence, was succeeded by the F-104G designed specially for the attack role at the request of West Germany. On the other side of the Atlantic, the McDonnell F-101A long-range interceptor was developed into the F-101C, with reinforced structure and skin for low-level penetrations, while interest in aircraft such as the Republic F-105 was revived. In Britain, designs such as the Blackburn NA.39 filled related operational requirements for the Royal Navy, while the Royal Air Force issued specifications for a new offensive aircraft, the TSR.2, which was to be designed, equipped and produced to break through defences around the target area at low altitude.

However, although military staffs insisted that aircraft originally designed primarily to engage air targets should be converted for operation against ground targets, they did not entirely dispense with interception missions. Nevertheless, as these missions were merely of secondary importance, they became subordinate to the primary requirements. *Diagram II* illustrates this development. It expresses in theoretical percentages

Diagram III: *General lay-out of an all-weather navigation and combat system for single-seat aircraft.*



I - NAVIGATION

- **Ground mapping.** Antenna of *Airborne Radar* depressed in elevation to scan the ground ahead. Pilot identifies pre-selected prominent check points (river junctions etc.) by comparison of *Radar Scope* picture with his radar map. Corrections can then be fed into the *Navigation Computer*.
- **Terrain avoidance.** The radar antenna is locked to point continuously ahead of the aircraft at a slight angle below the direction of flight. The *Radar Scope* indicates ground obstacles ahead of the aircraft and transmits steering signals in the pitch plane to the *Sighting Head*.
- **Navigation display.** Aircraft *Attitude* and *Horizontal Situation* (heading, TACAN radials etc.) are shown on the two instruments, left of the *Radar Scope*. The inner right-hand instrument indicates *Target Azimuth* (course to steer to reach it) and *Distance-to-Go* in nautical miles. The outer right-hand instrument gives *Drift Angle* and *Ground Speed*, measured by the *Doppler Radar*.

II - GROUND ATTACK

- **Target ranging.** With the radar antenna stabilized in roll and pitch, range information is passed to the *Bombing Computer* which calculates the solution to the bombing or missile launching problem.
- **LABS Methods.** The *Bombing Computer* calculates the release point of the bomb according to the method of attack employed, TAS (true airspeed), air density, height and drift angle. In an approach at low altitude using an IP (Identification Point) a known distance short of the target the delivery will be a high toss while the aircraft completes a half loop and roll off the top. Using the target as the IP the delivery will be "over the shoulder." In these examples the radar is switched to the ground map mode, the pilot flies low level over the IP toward the target, actuates a switch on passing the IP (on the *Radar Scope*), and the automatic pilot then commences the pull up into the half loop and roll. The *Bombing Computer* calculates the point of release according to the ballistic characteristics of the bomb and the safety distance required for the aircraft.

III - INTERCEPTION

- **Air search.** The radar is switched to the "search" mode and automatically scans ahead of the aircraft in elevation and azimuth. The antenna is stabilized in roll and pitch in this mode. Target response is shown on both the *Radar Scope* and the *Sighting Head*.
- **Lock-on.** When the radar has calculated the target's speed vector it can be locked on. The range information is then passed to the *Navigation Computer*, which in turn calculates the interception course to fly to launch air-to-air missiles. Approach and attack are carried out by following the steering orders appearing on the *Sighting Head*. This information includes time to go to firing distance, closing speed, firing point, and breakaway signal. For blind attacks the aircraft's attitude is also indicated on the *Sighting Head*.

the relative performance of interceptor and strike missions for aircraft designed some ten years ago and for the aircraft demanded today.

*

The expression "multi-purpose" has thus taken on a new meaning. There has always been a requirement for an aircraft capable of filling two different roles, but whereas yesterday this aircraft had to be, let us say, 75 percent interceptor and 25 percent strike aircraft, today these percentages have been more than reversed. What is demanded today is in general terms rather an aircraft capable of something like 80 percent offensive missions and 20 percent defensive missions.

Thus during the past ten years in Europe combat aircraft have passed through three stages, as shown in diagrammatic form on the previous page.

*

The different requirements for the defensive and offensive roles are also listed in this box. Two questions in particular have set manufacturers especially serious problems.

High-speed flight near the ground and the resulting fatigue of airframes is the first of these difficulties. An aircraft originally tailored for operations at 60,000 feet and above is not necessarily capable of withstanding the stresses and strains of prolonged flight at low altitudes. It is a well-known fact that the conversion of the Lockheed F-104 from an interceptor into the F-104G strike and low-level penetration aircraft necessitated major modifications. Similarly, the British devoted considerable time and effort to evaluating the operational advantages of low-level penetration and the relevant technical problems. The Blackburn NA.39 was then designed and built with the requirements of this new form of attack in mind. In France, the *Mirage III* has also been modified for this role.

Again it is no easy task to fit a single-seat aircraft with adequate equipment to ensure detection and destruction of an air target, accurate navigation at high and low altitudes, blind attack of ground targets and visual bombing. This is the second of the difficulties raised by the development of the pure interceptor *towards the multi-purpose aircraft now demanded by all air forces.*

As regards navigation, the system most widely adopted is one working on polar coordinates (Position and Homing Indicator or a similar system). This equipment displays on a dial the bearing and distance to go to a selected point on the itinerary, whose coordinates have previously been fed into the computer's control unit. Thus the aircraft can be guided from one check point to the next, including the target, and brought back easily to base. If wind values are fed in manually, the accuracy depends on the error arising from a faulty appreciation of the wind. However, the PHI can always be used in conjunction with other equipment, such as TACAN, doppler radar or a simple airborne radar tilted towards the ground so as to enable the navigation system to be checked with the aid of ground landmarks. It has also been proposed that the doppler or TACAN could be replaced by a particularly accurate inertial system which would enable the pilot, without recourse to any other equipment in-

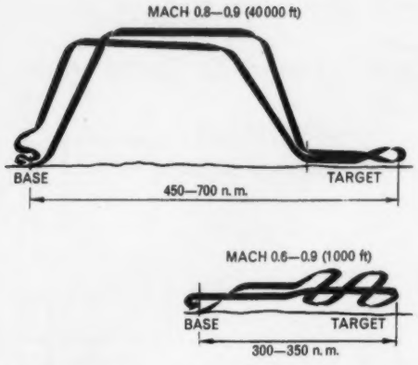


Diagram IV: Mission profiles for offensive operations by multi-purpose fighters at high altitude (top) and low altitude (bottom), in the latter case with very much reduced range.

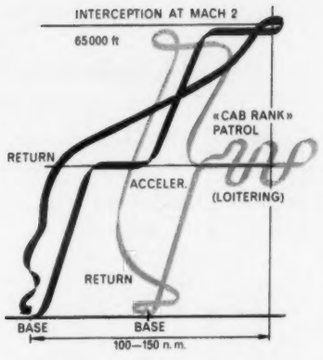


Diagram V: Mission profiles for defensive operations by multi-purpose fighters in pure interception (with an aerodynamically "clean" aircraft; black lines) and on patrol (with jettisonable external tanks; grey lines).

side or outside the aircraft, to determine his position to within $\pm$ 2 nautical miles after one hour's flying, i.e., after a distance of well over 500 nautical miles. But the disadvantage of inertial navigation systems is that they must be switched on long before the flight begins.

The combined use of these different airborne systems gives a single-seat aircraft the following new capabilities:

1. Ground mapping by means of the airborne radar, which shows the pilot a rough map of the terrain over which he is flying.

2. Terrain avoidance. Here the radar screen displays only that portion of the ground above—or on a level with—the altitude of flight selected by the pilot. With due safeguards added for terrain features just below the flight altitude, the pilot thus has a picture of the obstructions to be avoided. This radar image can be superimposed on the pilot's attack sight.

3. Profile flying also becomes possible. Here the airborne radar, tilted obliquely downwards towards the ground, functions as a telemeter and gives the pilot (human or automatic) the instructions necessary to keep within a given height above ground.

4. Attack against a ground target in level flight at low altitude or in shallow dive. Here the radar and the computers not only identify the point at which the manoeuvre must be initiated, but also furnish the distance between the aircraft and the target (provided this target produces an echo). If the aircraft carries LABS bombing equipment, various bombing methods become possible, such as toss bombing or long throw. The ground mapping mode of the radar shows the pilot the point at which he must initiate the bombing approach (which is then carried out automatically without further human intervention).

5. For interception missions, ground stations can still use UHF radio or a Data Link type system to pass instructions direct to the pilot. They can moreover provide remote control for the radar antenna and supply indications of distance and height of the air target to be destroyed.

Another aircraft designed for both defensive and offensive tasks is the Northrop N-156F *Freedom Fighter*, now undergoing flight tests (two General Electric J85 jets with reheat; Hughes TARAN navigation and weapons control system). Picture shows the N-156F with two *Sidewinder* infra-red air-to-air missiles.

Diagram III shows the various types of equipment used to give the modern fighter-bomber the operational capabilities described above.

These equipments, of course, receive the information required for their operation from the air data centre and the gyro centre. The air data centre not only feeds data to the pilot's instrument panel, but also supplies the PHI computer with the aircraft's true airspeed and the density of the ambient air. The gyro centre is the reference equipment for roll, pitch and direction or heading. This basic information is supplied to the artificial horizon on the instrument panel, to the computers for the navigation system and to the radar. The latter is thus stabilized in relation to all three reference axes.

*

Several different *integrated identification-navigation-bombing systems* are at present being flight tested in the United States, Britain and France. All are still in the experimental stage and none has yet emerged in its final form. However, certain general trends can already be discerned. Some argue that it has become possible to restrict the role of the gyro sight and to concentrate most of the information required for navigation or combat on the *radar screen*. Others maintain that piloting and attack could be simplified by projecting the information normally furnished by the radar onto the *sight*. Still others consider that the two functions should be separated, and that the pilot should have little difficulty in switching from one mode of presentation to the other as the flight advances. It is obvious, however, that the operational potential of the new fighter-bomber is so vast, and the duration of flight relatively so short that everything possible must be done to facilitate the pilot's task. After all, he is now being required to perform the same functions as were formerly entrusted to a crew of at least three men.

Such are the general features of the new single-seat combat aircraft, whether they be the Lockheed F-104G, the *Mirage III* strike version or the Saab *Draken*. Within certain limits, even lighter aircraft like the Fiat G.91 or the Northrop N-156F will have navigation aids such as the PHI or TACAN or even a doppler radar (G.91). On the other hand, the single-seat Republic F-105 heavy combat aircraft, which is to be ordered in large numbers for the USAF's Tactical Air Command, has a very comprehensive identification-navigation-combat system, which will enable it to carry out all offensive and defensive missions (see following article).

Thus, advances in electronics have finally led to the multi-purpose single-seat combat aircraft. One man can utilize it as an interceptor, air interdiction aircraft or bomber. Armed with an atomic air-to-surface missile or a nuclear bomb equivalent to several tens of kilotons, just one of these aircraft carries the same quantity of destruction as hundreds of old-style bombers. →→

2. The Republic F-105D Weapons System

Over seven years of development, five million engineering hours and a billion dollars were needed before the USAF's latest all-weather single-seat combat aircraft – the Republic F-105D *Thunderchief* – became operational. The fact that the USAF Tactical Air Command and Air Materiel Command embarked on this costly weapons project with Republic Aviation Corporation and followed it up with quantity orders, is one more proof that the manned fighter is by no means doomed to extinction.

There is not one guided missile of any category which can perform such a wide variety of tasks with the same degree of precision and reliability as this supersonic fighter-bomber. The following are only some of the missions which the USAF demands of the F-105D:

- *Destruction of the enemy's military potential* – transport of a large nuclear bomb over distances up to 900 nautical miles; dropping the bomb from low level at a speed of Mach 1+ (probable accuracy roughly 150–350 yards) or from high altitude at a speed of Mach 2+ (probable accuracy roughly 600–900 yards).
- *Support of ground forces* – dropping of high explosive, incendiary and napalm bombs, maching-gunning of ground targets and launching of air-to-surface missiles; for this role external loads up to 5 tons can be carried in addition to cannon, ammunition and internal bomb.
- *Destruction of enemy radar installations* – detection of radar stations by means of a special airborne radar homing device.
- *Armed reconnaissance.*
- *Destruction of enemy aircraft on the ground.*

The interception of high-flying aerial targets at speeds around Mach 2 is not among the missions originally specified for the F-105, and this heavy fighter-bomber will probably be used only occasionally for interception or patrolling airspace. The D version is nevertheless fitted with all the equipment necessary for semi-automatic all-weather fighter operations.

Ability to operate in all weathers was a decisive factor in planning the weapons system, as it was recognized right from the start that for many months of the year the fighter-bomber would encounter highly unfavourable weather conditions in Europe and Asia. The F-105D is thus not merely a combat aircraft which can carry out its mission in any kind of weather, but a weapons system with a high degree of automation, where navigation and piloting aids free the pilot so that he can concentrate on the most important decisions of the battle. Even approach-to-land can be made practically without the pilot's intervention.

Air superiority, which must be the main aim of any air force planning, can be achieved only if a force's manned and unmanned weapons systems can penetrate to their targets despite poor weather conditions and vigorous defence of enemy airspace. The guided missile does this when it works, but with a far lesser degree of accuracy. Manned tactical aircraft are more vulnerable to the enemy's defences than ballistic missiles, but they can escape detection by the enemy's radar, either by underflying the coverage zone or by electronic countermeasures. They can, if necessary, defend themselves while approaching the target, change course repeatedly and direct their bombs and missiles onto the target with deadly accuracy.

Admittedly, an IRBM squadron may cost less than a squadron of modern all-weather fighter-bombers, but manned aircraft can be used several times over: a fighter-bomber with semi-automatic piloting, such as the F-105D, constitutes, in effect, a reusable guided missile. Both in all-out atomic war and in local conflicts where it is essential to be able to destroy military point targets, it is a more versatile, more accurate and more mobile weapon.

These must have been the decisive considerations in the planning and preparation of the F-105. Republic Aviation is confident in the knowledge that the USAF will continue to use manned combat aircraft in Europe and Asia for at least 10 more years.

An integrated weapons system

In the creation of the Republic single-seat combat aircraft the concept of the weapons system was predominant: the USAF Tactical Air Com-

Republic F-105 with a 450-gallon underwing auxiliary tank.

mand demanded only the fulfilment of a variety of missions, and it was left to Republic to find an aircraft and auxiliary systems to meet these requirements. The result was a fully integrated weapons system, whose entire airborne and ground support equipment was tailored to measure. In this way designers ensured that equipment functions did not overlap, and that, conversely, nothing was omitted from the aircraft's auxiliary systems. As many components as possible have been standardized for ease of production and maintenance.

The most important dates in the history of the F-105D's development are as follows: Design work begun 1951; first prototype (XF-105A) flown October 22nd, 1955; single-seat day fighter F-105B tested May, 1956; first production F-105B delivered to USAF 335th Tactical Fighter Squadron May, 1958; first flight of all-weather F-105D July 9th, 1959.

In 1952, when the specifications for the fighter-bomber had been established, studies continued along several lines, until designers arrived at the basic conception of today's weapons system: A single-seat supersonic aircraft with an empty weight of over 12 tons, swept wings, conventional tail and high-volume stretched fuselage constructed according to the area rule to lower drag in the transonic range. The standard weapons selected were General Electric's M-61 six-barrel 20-mm rapid-fire cannon, whose present rate of fire is 6,000 rounds a minute when installed in the F-105.

In order to restrict the aircraft's weight and maintain its mobility, a single-seat configuration was chosen. This clearly required the development of automatic navigation and control aids and an almost fully automatic fire control system, and Republic, in collaboration with General Electric, the Laboratory of Electronics, Inc. and North American's Autonetics Division, evolved a system which completely satisfied Tactical Air Command.

It was further decided to carry the nuclear bomb in a 15-ft bay inside the fuselage. From here a hydraulic device can launch A- and H-bombs in such a way that, even at supersonic speeds, the bomb is not exposed to asymmetrical air loads as it leaves the aircraft, and can continue on its trajectory undisturbed. The launching mechanism can also serve to lift the bomb into the bay during loading. Advantages of internal bomb stowage are as follows: firstly, there is no additional external drag, and the aircraft can approach the target at its maximum speed of Mach 2+; secondly, the various electrical contacts between the nuclear bomb and the carrier are inside the fuselage and are thus not exposed to the air stream and the vagaries of the climate in zones where the weather is frequently poor; thirdly, if the bomb is suspended centrally there is less risk of its deviating from its planned trajectory as a result of aircraft roll or yaw at the moment of release. What is more, there is no external evidence to indicate whether or not a given F-105 is actually carrying an atomic bomb. The enemy, assuming he identified the aircraft in time, would otherwise take special defence measures which would endanger the success of the mission.

Chemical bombs, incendiary bombs or launchers for air-to-surface missiles with a total weight of up to 11,000 lb can be suspended from two pylons under each wing. Auxiliary fuel tanks of different capacities can also be fitted to these pylons and inside the bomb bay. The outer pylons are suitable for carrying *Bullpup* or *White Lance* air-to-surface guided missiles. Finally, for fighter operations the F-105D can be equipped with *Sidewinder* rockets or any other kind of air-to-air guided missile.

Robust airframe, impressive transport capacity

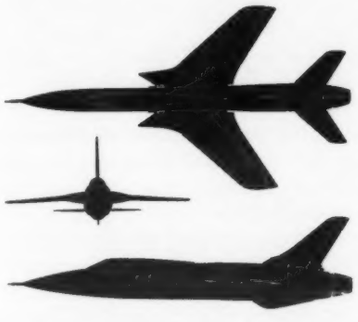
The Republic F-105 was designed for a safe load factor of 8.67 g with internal loads and a break load factor of 13g. This is the highest ever achieved for a combat aircraft. In high-speed, low-altitude operations the load factor is of decisive importance, for it determines the life and degree of vulnerability to fire of the airframe, which is subjected to heavy stresses during strike missions. In addition, the design of wings and tail must

The impressive array of rockets and bombs which the F-105 can carry in its bomb bay and on its four underwing pylons.

meet the special requirements for low-altitude fighter-bomber missions. The optimum airfoil for sharply varying loads, the ability to compensate for sudden changes in the centre of gravity, high stability for target approach, the lowest possible drag in the transonic range—these are but a few of the problems which faced Republic's engineers even when the project was still on paper.

Special care was taken in installing the equipment, which was not always easy to fit into the general design. This applied particularly to the hydraulic and electrical systems, to the comprehensive electronic equipment and also to the fuel

"Buddy" refuelling by another F-105 with underwing tank and probe-and-drogue system. Nearly 600 U.S. gallons of fuel can be transferred per minute, with the aircraft flying at near the speed of sound and relatively high altitude.



Technical data for the F-105D

Powerplant

One Pratt & Whitney J75P-19W	
Static thrust without afterburner	approx. 15,000 lb
Static thrust with afterburner	24,500 lb
Static thrust with afterburner and water injection	26,500 lb

Dimensions

Span	34 ft 11 in.
Overall length	64 ft 3 in.
Overall height (to tip of rudder unit)	19 ft 8 in.
Wing area	385 sq.ft.
Angle of sweep (at 25% chord)	45°

Weights

Weight empty	27,500 lb
Gross weight	35,200—48,400 lb
Fuel capacity:	
Fuselage tanks	approx. 1,200 U.S. gall.
Three external tanks at 450 gall. each	1,350 U.S. gall.
Max. fuel capacity (with large auxiliary tank in bomb bay)	2,900 U.S. gall.

Performance

Take-off run for average gross weight	approx. 2,600 ft
Take-off distance over 50-ft obstruction	approx. 3,300 ft
Take-off run for max. gross weight	approx. 4,590 ft
Take-off distance over 50-ft obstruction (max. gross weight)	approx. 5,900 ft
Sea level rate of climb (average gross weight)	approx. 34,400 f.p.m.
Service ceiling	more than 50,000 ft
Max. sea level Mach number	1.25
Max. Mach number at 36,000 ft	2.15

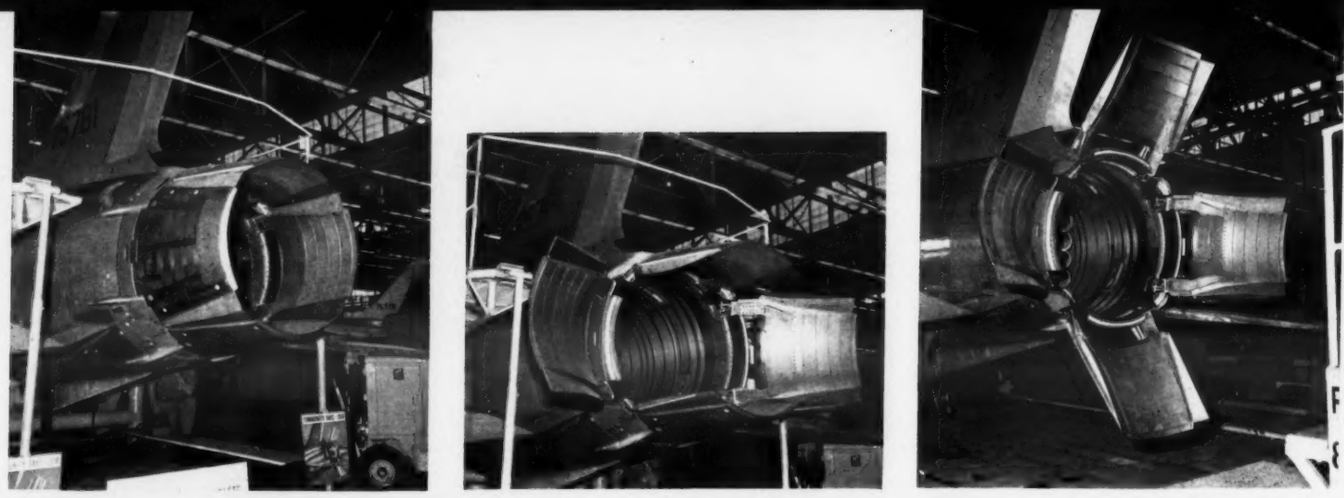
tanks. Fuel is stored entirely in the fuselage above the engine and its intake. There are no tanks on the vulnerable underside of the airframe.

The shallow, projecting engine intakes represent an unusual solution. Up to a million cubic feet of air per minute pass through the intakes, which have variable geometry to ensure that the engine is not stalled by supersonic shock waves during any phase of the flight. In addition, the special design of the intakes enables them to "split" certain shock waves so as to reduce adverse effects on the tail. Thus the intake shape selected not only improves engine performance, but also increases stability in the transonic range. The wings have both leading and trailing edge flaps, and the ventral fin under the rear fuselage and the all-moving one-piece tailplane increase stability in supersonic flight.

The *Thunderchief's* proven jet engine (Pratt & Whitney J75P-19W) has doubtless made a considerable contribution to the aircraft's safety record: some 100 service pilots have flown the F-105, between them logging over 5,000 flight hours, without a single serious accident. Handling is further simplified by the four-petal speed brakes in the rear fuselage which, when shut, enclose the jet pipe. These can be set in the following four positions: Position 1 – fully closed (cruising without afterburner); position 2 – slightly open (to enlarge jet orifice when using afterburner); position 3 – both side-petals fully open (for control and braking, particularly when landing); position 4 – all four petals fully open (airbrake application). The brakes can be operated over the F-105's whole speed range.

The JF-105D reconnaissance version (earlier known as the RF-105D).

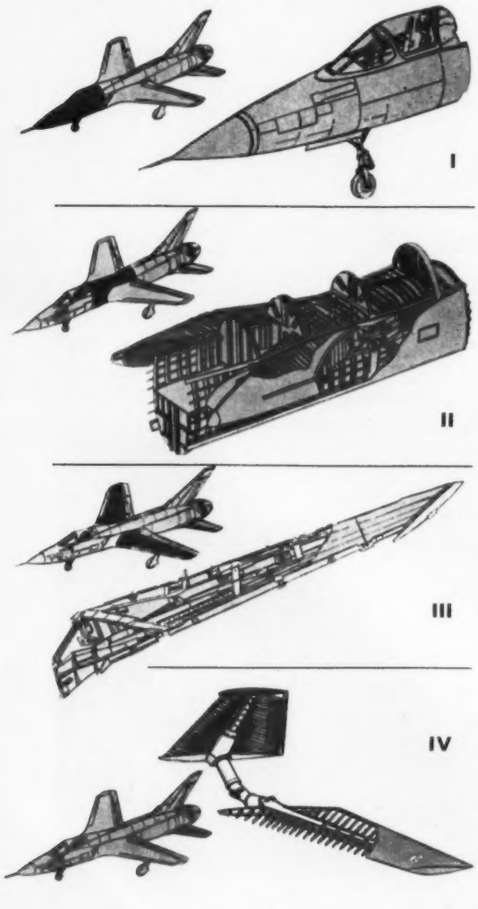
The men standing beneath the F-105 wing give an idea of the *Thunderchief's* size.



When in normal position, the air brakes at the rear of the F-105 enclose the jet pipe, but can be opened step by step to an angle of roughly 40°. The left-hand picture shows the petals almost closed, in the position which would be selected when the afterburner is in operation. In the centre picture the two side sections are fully open (as braking aid during landing approach with undercarriage lowered and control aid in certain flight conditions). Right, the four sections in fully open position (air braking during rapid descent).

The F-105D's performance is impressive for an aircraft of this weight class (20 tons): speeds without external loads are around Mach 1.25 at sea level, and around Mach 2.15 at 36,000 ft. The aircraft has flown at supersonic speeds even without the afterburner. With the afterburner and water injection the interceptor version can reach a height of about 40,000 feet two minutes and one second after leaving the runway. Only 55 seconds are required for the aircraft to release its brakes and climb to a height of 8,500 ft. The service ceiling is above 50,000 ft; and after acceleration to maximum speed at a height of about 36,000 ft and a zoom climb the aircraft can manoeuvre even at heights around 70,000 ft. Near the peak of the ballistic climb phase the air-to-air missiles can be fired to even greater heights. At supersonic speeds and heights around 40,000 ft the F-105D can turn with accelerations up to 5.5 g.

The main sub-assemblies of the F-105D: I. nose section with nose wheel and cockpit; II. fuselage centre section with air ducts for the engine, and wing attachments; III. wing; IV. all-moving tailplane with central connecting tube.



An idea of the *Thunderchief's* transport capacity is given by the following example of a typical long-range mission: With a take-off weight of roughly 47,000 lb and carrying about 1,200 U.S. gall. of fuel in the internal tanks, three external tanks with a total capacity of 1,350 U.S. gall. and a nuclear bomb weighing 3,300 lb, the F-105D has an operational radius of 800 to 900 nautical miles, if it approaches its target at subsonic speed at heights between 30,000 and 36,000 ft. In this mission there is still enough fuel, not counting the normal reserves, for a three-minute, low-level supersonic flight with reheat.

For ground support duties over a short range the F-105D can carry 190 70-mm unguided missiles in five launchers under the fuselage and wings, or four 1,000 lb bombs and a 450 U.S. gall. auxiliary tank, or any other desired combination of auxiliary tanks and weapons weighing up to 11,000 lb. For ferry or patrol flights with three external tanks and a large auxiliary tank in the bomb bay, the F-105D has a total fuel capacity of 2,900 U.S. gall., giving it a range of well over 2,000 n. m.

All production F-105Ds are fitted with a retracting probe for in-flight refuelling at high altitudes. They are refuelled by four-engine KB-50J piston-engine aircraft or by other F-105Ds fitted with a drogue and two "buddy" tanks under the wings. Later, however, TAC will be receiving four-jet Boeing KC-135 *Stratotankers*, which will give the *Thunderchief* global mobility.

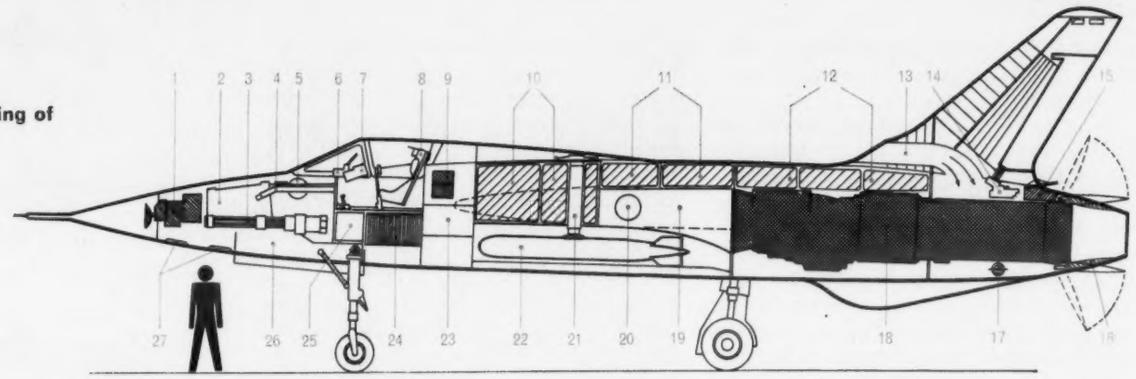
Combined navigation and fire control system

The F-105D's versatility is attributable in the first place to its integrated all-weather navigation and fire control system. One of the essential components of this system is the AN/APN-131 doppler navigator, designed by the Laboratory for Electronics Inc., of Boston, Massachusetts. This installation comprises a doppler radar, several flight data pickups, a flight data computer and a navigation computer. It continuously plots the coordinates of the aircraft's position, the ground speed and track, course and distance to the next check point or to the target and finally wind direction and force. These values are fed into the autopilot and also displayed on the instrument panel. The pilot himself has no dead reckoning to do. Republic stresses that the various components of the system have been so perfected and tuned to each other that the doppler navigator and autopilot can take the heavy fighter-bomber to its destination with a maximum error of 0.5 percent of the distance covered. The integrated system also includes the R-14A NASARR (North American Search and Range Radar). It was developed by the Autonetics Division of North American Aviation, works as a monopulse radar in the X-band and has an elliptical reflector measuring roughly 18 inches by 24 inches. The radar maps of the terrain painted by the R-14A enable the pilot to correct any minor errors occurring in the doppler navigator and to identify his target. In addition, NASARR performs the following functions: warning the pilot of obstructions along the route (terrain avoidance), continuous measurement of target slant range for all weapons, identification and pursuit of air targets.

The aircraft's equipment also includes the General Electric FC-5 three-axis autopilot, which is coupled to the doppler navigator and holds the aircraft constantly on a great circle course, and even takes over control during climb and landing approach.

So that the air-to-surface weapons can be placed accurately on target even at night or in the worst possible weather conditions, a special fire control system was developed for the F-105 (General Electric AN/ASG-19). This uses a ballistic computer, the doppler navigator and other aids to solve all the problems arising in connection with bombing. The system, which together with NASARR is dubbed *Thunderstick*, automatically initiates the flight manoeuvre for bombing, makes allowance for cross wind influences and air density, stabilizes the aircraft during the final target approach phase and controls the bomb release. It permits of automatic blind bombing from a shallow dive, from a low altitude

Section drawing of the fuselage:



with subsequent half loop (long toss or over the shoulder) or from level flight at high altitude. When ground targets are to be attacked in support of the combat troops, the *Thunderstick* system controls the dropping of chemical bombs and the launching of unguided air-to-surface rockets. Finally, in fighter missions it provides fire control for the M-61 cannon and the air-to-air missiles.

*

1. R-14A NASARR
2. Ammunition container for the 20-mm cannon shells.
3. General Electric M-61 20-mm cannon.
4. Probe for the in-flight refuelling system.
5. R/T communication equipment.
6. Sighting head with combining glass.
7. NASARR indicator.
8. Ejection seat.
9. Air-conditioning and pressurization equipment.
10. Fuel tank.
11. Fuel tank.
12. Fuel tank.
13. Intake for afterburner cooling air.
14. Rudder servo control.
15. Stowage space for brake parachute.
16. Air brakes.
17. Tailplane bearing.
18. P&W J75P-19W jet.
19. Air intake for engine.
20. Additional engine air intake for use in wheels-down flight.
21. Hydraulic bomb hoist and carrier.
22. Nuclear bomb.
23. Hydraulic and electric bay.
24. Communications, identification and navigation equipment.
25. Undercarriage hydraulic bay.
26. Nose wheel bay.
27. Antennas.

The Thunderchief in operation

Let us now follow an F-105D on a typical atom bomb mission against a "hardened" ground target at a range of some 800 nautical miles. While the ground crews are preparing the aircraft, the pilot studies the radar pictures of the approach route taken on earlier reconnaissance flights. Then the fully-fuelled F-105D taxies to the take-off point in pouring rain, lifts off with afterburner roaring and climbs to more than 30,000 ft. During this time the pilot has switched on the autopilot, which ensures that the optimum climb angle and the prescribed rate of climb are maintained. On reaching his cruising altitude, the pilot need only reset his speed and heading. Before take-off, a small programming element has been inserted in the navigational computer, thus feeding in the coordinates (geographical latitude and longitude) of the target and the first check point (C.P.). The autopilot then takes the aircraft, without further action by the pilot, to above the check point or at any rate to its vicinity. As soon as the aircraft is sufficiently close, the pilot compares the radar image of the check point (e. g., confluence of two rivers) with the radar prediction map. If the actual radar image reveals that the aircraft is off track, the pilot measures the off-track distance on the radar screen and feeds it as a correction into the navigational computer. The latter then uses the new initial values to compute the data for the flight to the next check point. Check points are

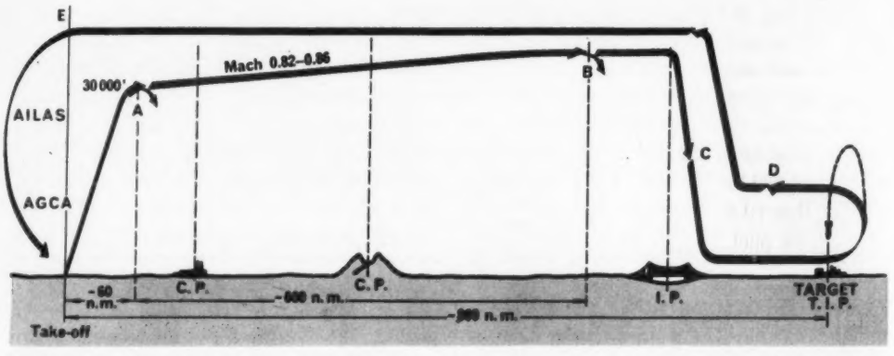
Inside the final assembly shop at Republic's Farmingdale plant.

selected at intervals of about 200 nautical miles, so that the pilot can repeat his corrections every 20 minutes.

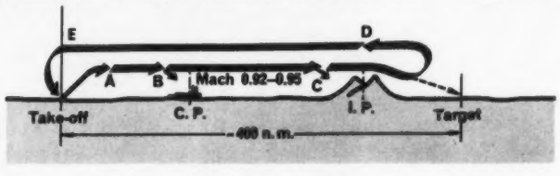
When the aircraft is within, for example, 100 nautical miles of the target, the pilot begins the descent, since the target approach is to be made at supersonic speed and near the ground, below the enemy's radar coverage. It is assumed, for the present example, that the target is hidden in mountainous country and that the pilot must hug several valleys in order to reach it. In this case he switches his radar during descent to the "terrain avoidance" mode, whereupon the radar antenna scans the area ahead within a given altitude range above and below the aircraft's line of flight. This altitude bracket can be selected by the pilot at between zero and 6,000 ft above and below the aircraft's level. By watching the changing radar image, the pilot can pick out the most favourable approach route. The "terrain avoidance" mode can also be used for a lengthy level flight near the ground. The pilot can select the warning distance (i. e., the slant distance from the radar reflector to the obstruction) by adjusting the range cursor on his radar screen. Both the ground mapping mode and the terrain avoidance mode can be displayed on the combining glass of the sighting head by means of a projection system, so that the pilot need not lower his eyes.

Next the pilot sets the proposed attack method on a selector switch on the fire control system. This method can be bombing from a shallow dive, long toss or over-the-shoulder bombing from a half loop. In this particular case it is assumed he elects to make a long toss. As soon as he has made out the target on his radar screen, he steers the aircraft in such a way that the radar echo from the target coincides with the vertical centre line on the screen. He then continues to approach the target until its echo moves down this line to the range cursor previously set on the radar. At this moment the pilot pushes a button setting the automatic bombing computer in operation. The latter is fed with basic data from the radar (distance and direction to target), the doppler navigator (ground speed and drift) and gyro centre (changes in attitude), and makes allowance for the ballistic values of the bomb and the air density. The entire bomb release system is so coupled with the autopilot that, once the above-mentioned button has been pushed, the aircraft maintains its heading. Before the aircraft begins to pull up, the bombing computer is busy working out the optimum moment for bomb release. As soon as the correct conditions for an accurate drop are achieved, it gives the release signal. The action of pushing the button to set the bombing system in operation also retracts the bomb bay doors. At the same time a roll stabilizer comes into action to hold the wings level. As the cross wind over the target area is automatically measured by the doppler radar and fed into the autopilot, the human pilot can literally sit back with his hands in his lap—once he has picked up the target on his radar screen and pushed the aforementioned button—until the half loop has been completed, the aircraft has rolled into normal attitude and is moving away on a reciprocal course at a safe distance from the scene of the explosion.

On the homeward flight the pilot uses another series of check points until he reaches base, where



Mission profile for a fighter-bomber sortie with nuclear bomb—high-altitude approach. With a gross weight of roughly 48,400 lb and three auxiliary fuel tanks, the F-105D climbs to 30,000 ft. The pilot jettisons the centre tank at point A, flies over a number of check points (C.P.), jettisons the two underwing tanks at B, commences the descent after passing the identification point (I.P.), switches the NASARR to "terrain avoidance" at point C, approaches the target at supersonic speed and low altitude, switches on the automatic bomb release and sits back until he reaches point D. Here he takes over again, climbs to optimum cruise altitude and returns to base. At E the automatic landing approach begins, with the aid of AILAS (Automatic Instrument Landing Approach System).



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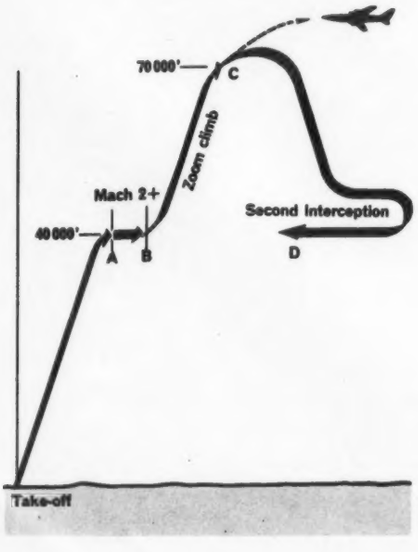
Mission profile for a fighter-bomber sortie with nuclear bomb—low-level approach. The pilot switches his radar to "terrain avoidance" soon after take-off, at point A. The centre tank is jettisoned at B, the two others at C. Above the identification point (I.P.) the pilot switches on the afterburner and then the automatic bomb release, whereupon the aircraft approaches the target at supersonic speed, drops the bomb from a shallow dive and begins the return flight after a half loop. At D the pilot again takes over the controls and begins the landing approach at E.



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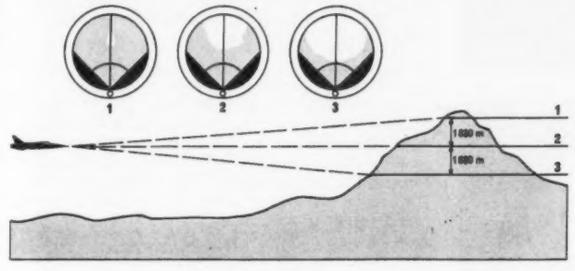
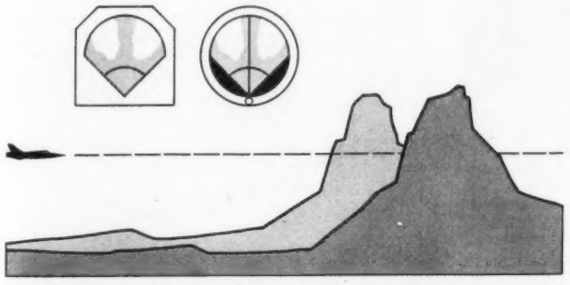
Mission profile for an interception with air-to-air guided missiles. After take-off the F-105 climbs with the aid of its afterburner to a height of 40,000 ft. The pilot levels out at A, accelerates to over Mach 2, then puts his aircraft into a zoom climb at B. Using its own kinetic energy, the F-105 next climbs to 70,000 ft to fire its air-to-air rockets at C, near the peak of the ballistic phase. It descends to 40,000 ft and waits at D for a further interception command.

These five front views with different external loads show some of the typical weapons which can be carried by the F-105D:

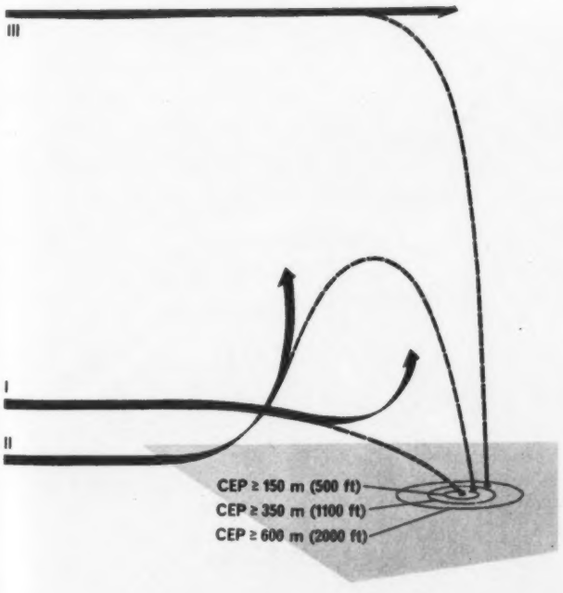
I Three auxiliary tanks, each with a capacity of 450 U.S. gall., under the wings and fuselage, with a nuclear bomb in the bomb bay;
II Four 1,000 lb H.E. bombs under the wings, a 450 U.S. gall. auxiliary tank under the fuselage and a large auxiliary tank in the bomb bay;
III Up to 190 70-mm air-to-surface missiles in five launchers under the wings and fuselage;
IV Three auxiliary tanks, each with a capacity of 450 U.S. gall., under the wings and fuselage and a large auxiliary tank in the bomb bay (for ferry flights or escort missions);
V Four air-to-air rockets for interception.

A formation of F-105 *Thunderchiefs* flying at high altitude.





Terrain avoidance by NASARR. The beam scans ahead of the aircraft and can be adjusted to cover an airspace extending up to 6,000 ft above and below the flight path at a predetermined range. The upper illustration shows the pattern of returns that would appear on the radar scope in relation to the three scan levels. By flying the aircraft so that the radar trace just disappears from the screen, the pilot can ensure that he will clear any ground obstacles by a preset altitude. The second illustration shows the equipment being used to guide the aircraft between obstacles, together with the representation of the radar picture as it appears on the radar screen and the sight head.



The three bombing methods of the F-105D—from a shallow dive (I), from low altitude followed by a half loop (II) and from horizontal flight at high altitude (III)—have different degrees of accuracy. Method I, with a probable accuracy better than 500 ft (visual bombing), is by far the most precise, followed by Method II with a probable accuracy of better than 1,100 ft. The latter accuracy can be obtained both for low toss and over-the-shoulder bombing. The least accurate is, of course, bombing from altitudes between 40,000 and 50,000 ft, but even in this case the precision achieved is at least that of the SAC's eight-jet bombers.

he is guided to a landing by means of his Automatic Instrument Landing Approach System (AILAS). The same navigation, radar and fire control system can also be used for high-altitude attacks on inaccessible or strongly defended ground targets and even for interceptor missions.

Substantial contracts...

The *Thunderchief* has been chosen to become Tactical Air Command's main weapon. Two F-105A prototypes, three RF-105 reconnaissance models and more than 80 F-105B day fighter-bombers have already been built, and production of the F-105D all-weather version has begun. During fiscal 1960 orders have been placed for 75 F-105B fighter-bombers and 59 F-105D all-weather fighter-bombers, but Tactical Air Command has asked for appropriations in fiscal 1961 for production of an additional 225 F-105Ds. If the USAF continues to make the same use of the production capacity at Farmingdale until 1964—and Republic has little doubt that it will, in view of Government investment in new production equipment—Tactical Air Command will have a fighter-bomber force of more than 900 F-105Ds by the end of 1964 or beginning of 1965. These could then replace a large percentage of the F-100s stationed in Europe and Asia. A first wing, 4th Tactical Fighter Wing at Seymour-Johnson AFB, N. Carolina, is already equipped exclusively with *Thunderchiefs*.

Quite apart from orders from the USAF, Republic has submitted to the European NATO members an F-105 production programme under which these countries could produce the aircraft under licence at a guaranteed unit cost of $1.4 million (assuming a total output of some 250 aircraft).

Needless to say, the *Thunderchief* is constantly undergoing improvements. For example, installation of a more powerful version of the Pratt & Whitney engine would enable take-off distance to be reduced or gross weight to be still further increased. Above all, however, it is planned to fit new reconnaissance equipment, with special radar and infra-red detectors, which would render the F-105 capable of combined search and attack missions (strike reconnaissance) at night and in bad weather. This equipment will enable the pilot to watch, on a special screen, radar and infra-red pictures (of high resolution) of the terrain flown over, detect mobile targets and attack "blind." Cameras coupled with flares will take night photographs from medium and low altitudes. The whole equipment could be installed in the F-105's bomb bay, when the weapons would be suspended on underwing pylons.

It is an open secret that Republic is working at full pressure on a VTOL single-seat combat aircraft, which could replace the F-105s in Europe and Asia at a later date—somewhere around the end of the sixties. Meanwhile, however, F-105Ds will be held in readiness on the NATO bases and at some of the USAF bases in Asia. Even today, the Republic aircraft can be described as *Tactical Air Command's complement to Strategic Air Command's weapons systems.* ←←

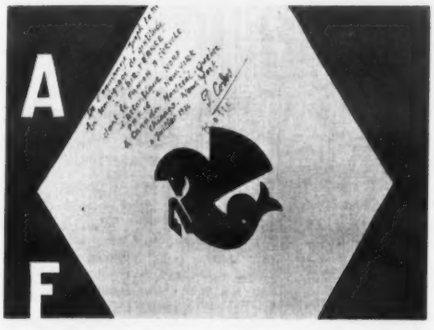
The series on "Multi-Purpose Single-Seat Combat-Aircraft" will be continued in the next issue with an article on the *Mirage III*.

What's in the Air?

● **U.S. civil aviation officials** looked forward to the Netherlands-U.S. air talks with a certain pessimism, and the outcome of negotiations has shown this attitude to be fully justified. The negotiations for a KLM air route to Los Angeles, which began on January 7th, were interrupted ten days later when Secretary of State E. G. Stijkel, the leader of the Netherlands delegation, returned to the Hague for consultations with his Government. The second round of talks began on January 25th and ended on February 3rd in a "strained" atmosphere. The United States authorities have refused the Netherlands application, confirming the stand taken at the negotiations in spring, 1957, when KLM received permission to land at Houston, Texas. In the Netherlands itself there is bitter disappointment over the breakdown of the talks. Foreign Minister Dr. Luns said that the United States' action constituted discrimination against the Netherlands who, in 1957, had been among the first of the European countries to request landing rights at Los Angeles. Both Dr. Luns and KLM President I.A. Aler said that it is evident that the United States' air policy is based on protectionism, under strong pressure from American carriers. Aler said that the Netherlands is being penalized for the fact that, from the geographical point of view, she is a small country. But for that very reason she is dependent on overseas earnings from air transport and international trade. In his statement Aler says, however, that the Dutch arguments cannot eventually fail to convince the United States Government, and KLM is confident that the Netherlands Government will continue these negotiations to secure a reversal of the present decision.

● **U.S. Civil Aeronautics Board Chairman** James R. Durfee has told the Chairmen of the House and Senate Commerce Committees that Great Britain and Russia are subsidizing the development of supersonic transport aircraft, and that U.S. firms may lose the race unless they receive prompt help and funds from the Government. A delay of one to three years by U.S. manufacturers could mean that United States long-range carriers would be forced for competitive reasons to place orders abroad. Durfee said that the four largest U.S. aircraft manufacturers—Boeing, Convair, Douglas and Lockheed—could each produce a supersonic model, given proper financial encouragement. Durfee said that the supersonic transports' high speed and the fact they would be unprofitable on sectors of under 1,500 miles would limit the global requirement to between 100 and 200 aircraft. This restricted market, plus the high research and development costs, would mean that not more than two manufacturers could turn out production models with a profit. It was therefore likely that the first one or two manufacturers in the field would capture the entire market.

With regard to these statements, Lockheed spokesmen said that a supersonic commercial transport weighing 250,000 lb would probably cost about $160 million to develop. Cost per aircraft would be $9,240,000 based on a production programme of 200 aircraft, or $11 million on a 100-unit schedule. Lockheed's studies show that a Mach 3-3.4 commercial transport could be operational by 1965.



Paul Codos, well-known French pilot and North Atlantic pioneer, died in Paris at the end of January, aged 64. After his second Atlantic crossing with Maurice Rossi in May, 1934, he was received at the White House by President Roosevelt (upper picture). Maurice Rossi is at far left. On a later trans-Atlantic flight the Blériot "Joseph Le Brix" carried an Air France flag, on which Codos and Rossi marked the distance they had covered (lower picture).

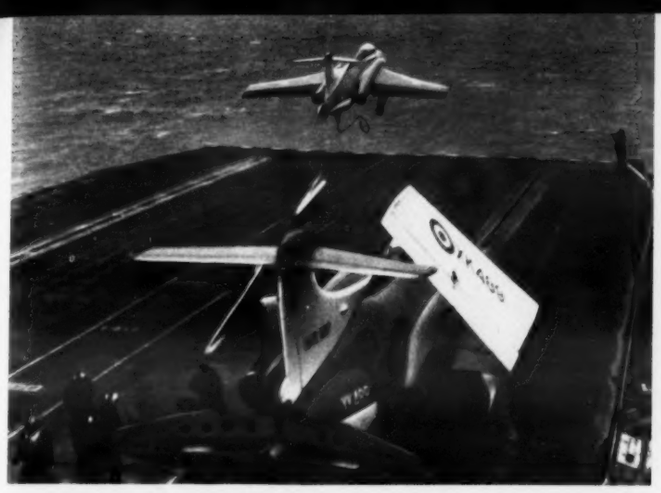
● **British Overseas Airways Corporation** has announced plans to resume services to Cairo on April 10th, after a lapse of three and a half years. BOAC plans to operate four *Comet 4* round trips weekly from London through Cairo to points in Pakistan, India and the Far East. BOAC will continue to serve Beirut and Istanbul, both cities added to the carrier's route following the withdrawal of service to Cairo in October, 1956.

● **Sud-Aviation and Douglas Aircraft Company** have reached an agreement on the licence manufacture and sale of the *Caravelle*. In addition to giving Douglas an option on rights to manufacture the *Caravelle* under licence in the United States, the agreement covers cooperation in other technical and business projects. Douglas will participate in future development of the *Caravelle* series, and a number of employees are to be interchanged for training purposes. Douglas will have sales rights for the *Caravelle* in the U.K., Australia, most of the Western Hemisphere, Japan, India, Pakistan and other areas of Asia, plus substantial portions of Africa and the Middle East. Sud-Aviation retains rights in Continental Europe and French-speaking areas. Douglas's plans for *Caravelle* sales and servicing will include ground and flight training for airline personnel, and spares depots will probably be established in New York and California. Douglas confirmed that the DC-9 project has now been abandoned.

● **Canadair Limited** will pass down contracts valued at over $25 million for components of the 200 CF-104 strike-reconnaissance aircraft ordered for the RCAF. A $2.6 million contract for air intake scoops and ducts has already gone to Avro Aircraft Ltd. of Toronto; a second, valued at $2.4 million, for forward

Passengers on United Air Lines' Douglas DC-8 jet airliners at San Francisco International Airport use these telescoping, covered "Jetways," which lead direct from the finger exits to the aircraft.

Shell Nederland Verkoopsmaatschappij N.V., of The Hague, has ordered two of these large airfield refuelling trucks, with a capacity of 8,800 Imp. gall. The trucks, built by Van Doorne's Automobielenfabriek (DAF), Eindhoven, are to be used mainly for refuelling KLM's Douglas DC-8s at Schiphol Airport, Amsterdam. The maximum delivery rate is 550 Imp. gall./min., and the trucks are fitted with a device which automatically and instantaneously turns off the fuel supply when traces of water are detected.



fuselage structures, has gone to Canadian Car Co. Ltd., of Fort William, Ontario. Orenda Engines Ltd., of Toronto, has already received engine orders to the tune of $80 million. The first CF-104 is scheduled for test flight at Canadair's Montreal plant in spring, 1961, and all 200 aircraft are due for completion by the end of 1962. Canadair has also received subcontracts to the value of over $4 million from Lockheed's California Division for work on the F-104G *Starfighters* in production for the German Air Force. The Canadian company is to produce the empennage, complete wing and aft fuselage.

● **French aircraft manufacturer Max Holste** recently visited the United States for discussions with top executives of Cessna Aircraft Co. The U.S. company is reported to be interested in acquiring either sales and service rights or licence production rights in the United States for the Max Holste *Super Broussard*. It has also been suggested that Cessna may acquire a minority holding in the capital of Avions Max Holste.

● **Raytheon Company and CSF** (Companie Générale de Télégraphie Sans Fil) have signed a new agreement covering the exchange of technical information and in particular the development of inverted-wave electronic tubes such as CSF's carcinotron and Raytheon's amplitron.

● **A Porter P.6** has been chartered from the Pilatus Aircraft Works, Stans, Switzerland, to accompany the Swiss 1960 Himalaya Expedition. This will be the first occasion when an aircraft of this category has been employed for the transportation of men and equipment to such high altitudes. The Swiss party plans to climb the 26,826-ft Dhaulagiri peak; the Pilatus *Porter* will operate from the lower levels to the 18,372-ft icefield at the Dhaulagiri north-east pass. The *Porter* will be flown to Nepal at the beginning of March.

● **The Federal German Defence Ministry** has increased the number of Fiat G.91 strike fighters to be acquired from 200 to 282. The first 50 G.91s are to be imported complete from Italy, and the balance is being produced under licence in West Germany.

The Blackburn NA.39 strike aircraft, ordered in large numbers by the Royal Navy, has completed trials on the aircraft carrier Victorious. *Pictures show an NA.39 about to make a deck landing (top right) and an NA.39 being launched from the* Victorious' *left-hand catapult while a second NA.39, with wings folded, is being prepared for launching from the right-hand catapult. The lower picture shows an NA.39 with folded wings and nose and tail brakes open, being put into a hangar under the deck.*

● **Two English Electric Canberra B.2s** are to be used as all-weather radar trainers by the Royal Swedish Air Force. The first was recently delivered to Barkarby military airfield near Stockholm.

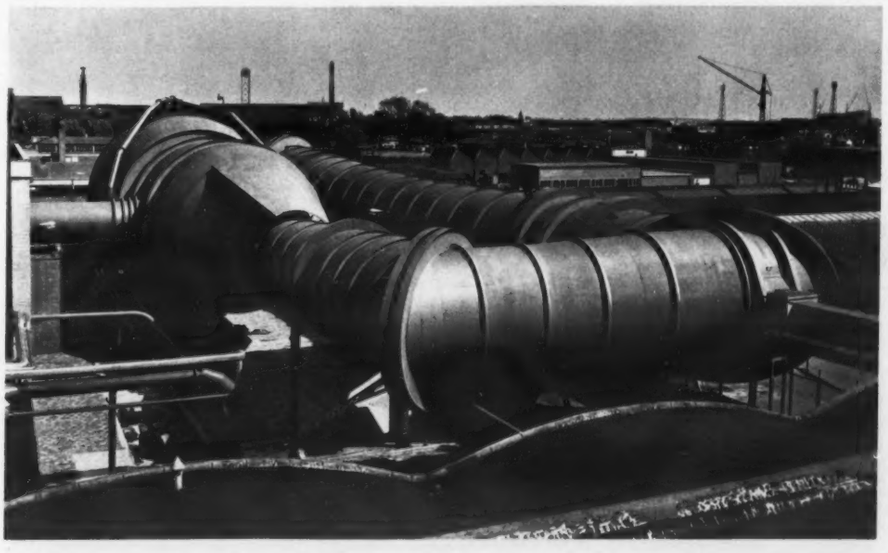
● **No.10 Maritime Reconnaissance Squadron** of the Royal Australian Air Force is to get twelve new Lockheed P2V-7 *Neptunes* to replace its obsolete *Lincolns;* delivery is scheduled for January, 1961. No.10 Squadron's crews will carry out conversion training on modified P2V-5s operated by No.11 Squadron.

● **Douglas Aircraft and the U.S. Federal Aviation Agency** are to adopt a new numerical designation to differentiate between various models of the Douglas DC-8 airliner. They will henceforth be known as: Domestic, P & W JT3 engines—10 series; Domestic, P & W JT4 engines—20 series; Long Range Intercontinental, P & W JT4 engines—30 series; Long Range Intercontinental, Rolls-Royce *Conway* engines—40 series; Long Range Intercontinental, P & W JT3D turbofan engines—50 series. Three of the versions, the 10, 20 and 30 series, have been certificated by the FAA.

● **Aviation Traders** is converting Douglas DC-4s for use as car ferry or freight aircraft. The converted aircraft, designated ATL.98, will have completely rebuilt

The Air Partner *turbostarter, developed by Atlas Copco AB, Stockholm. This equipment can also be used to ventilate and de-ice jet aircraft. Forty-three* Air Partners *have been ordered to date.*

The Netherlands National Aeronautical Research Institute (Nationaal Luchtvaartlaboratorium NLL) has placed in service a new wind tunnel for flow speeds between Mach 0 and Mach 1.3 (approx. 0 to 1,500 ft/sec). The test section is 5 ft 4 in. high and 6 ft 8 in. wide, and the tunnel is driven by a 20,000 h.p. compressor.



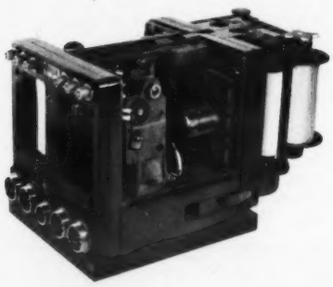
The Mirage IIIB, *two-seat version of the Dassault fighter, among whose roles is the training of pilots in all-weather flying. The* Mirage IIIB *can be regarded as a direct derivation of the single-seat* Mirage IIIC *and can be rapidly converted for combat operations, using only normal air base resources.*

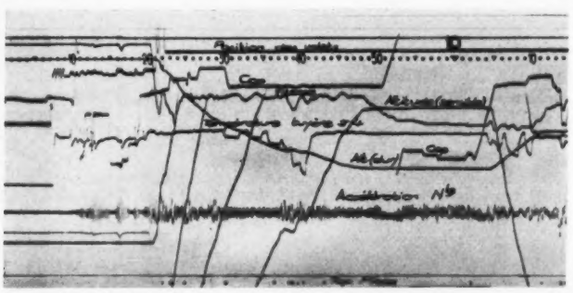
The February issue of Interavia *Review reported the choice of the Breguet 1150* Atlantic *naval reconnaissance and anti-submarine aircraft to equip a number of NATO units. This sketch gives an impression of the external appearance of the* Atlantic, *which will be powered by two 6,000+ e.h.p. Rolls-Royce* Tyne 20 *propeller turbines. The all-up weight will be about 40 tons, the wing span 124 ft, the length 90.2 ft. Cruising speed will be 320+ knots, endurance over 12 hours. The* Atlantic's *crew will consist of 12 men.*

The two-seat Canadair CL-41 trainer began flight tests in mid-January. It is powered by a Pratt & Whitney JT12 (J60) jet engine delivering 2,400 lb thrust and reaches speeds in excess of 410 knots.

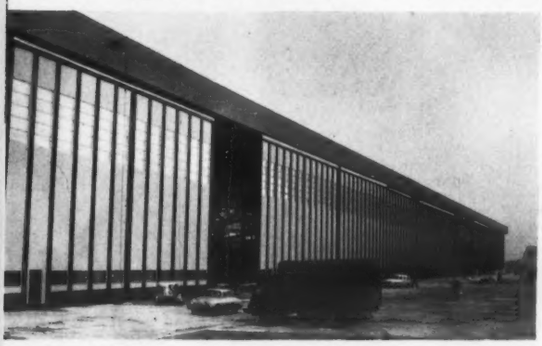
The two-seat Kiebitz *slow-flying aircraft developed by Professor Winter and the Aircraft Construction Department of the Brunswick Institute of Technology. The aircraft, which is of mixed construction, is powered by a 90 h.p. Continental C-90-12F engine and has a wing span of 35.1 ft and wing area of 159 sq. ft. Weight equipped is 990 lb, take-off weight 1,510 lb. Maximum speed 89 kt; stalling speed with flaps down 27 kt; take-off run approx. 250 ft; landing run 130 ft.*

Société Française d'Instruments de Mesure (SFIM), of Massy (S.-et-O.), produces a wide range of measuring instruments and photographic equipment for recording flight data. The picture shows the Type A261 recording equipment, which can inscribe ten parameters continuously and two parameters intermittently on a photosensitive tape 90 mm wide and 50 ft long. The equipment, which will operate for 100 hours, also records a time reference (GMT). Installed weight 22 lb; dimensions 12½ × 7½ × 6¾ in. The tape, also illustrated, records time reference, course, airspeed, altitude, temperature in the engine jet-pipe and acceleration. SFIM also produces airborne instruments and measuring equipment for industrial purposes, while its research department is studying new problems concerned with the navigation, control and stabilization of helicopters, fixed-wing aircraft and guided missiles.





One of the world's largest metal hangars has been completed at Paris-Orly Airport: length 1,000 ft, breadth 173 ft, clear height at doors 50 ft. This hangar, four fifths of which will be let to TAI and one fifth to TWA, will accommodate six aircraft the size of the Boeing 707 or eight the size of the Caravelle. *At the back of the facility are workshops, store-rooms for spares, garages, offices, lounges and a restaurant. The metal structure of the hangar weighs roughly 1,000 tons. The six double doors, weighing 30 tons each, are opened and closed electrically.*



forward fuselages and nose loading doors. The first batch of ten is under conversion and should be ready for delivery by the end of the year.

● **Three Northrop T-38 Talon jet trainers** are undergoing flight tests, and a fourth was delivered to Northrop pilots at Edwards AFB in mid-February. The T-38 will probably be operational by April, 1961. Flight tests on the N-156F fighter version are continuing parallel with those on the T-38.

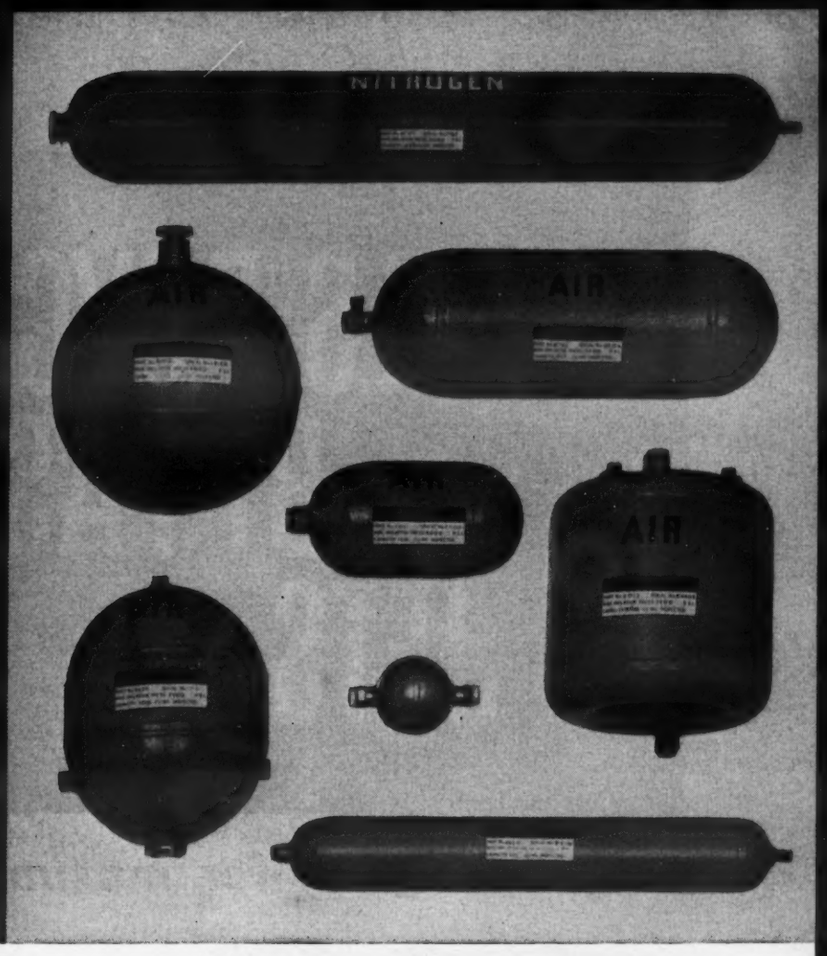
● **The Boeing 707-520** will be powered by Rolls-Royce *Conway RCo.42* by-pass engines, each delivering 20,250 lb thrust. Gross weight will be 340,000 lb. By comparison, the 707-420, which is about to be placed in service, is powered by *4 Conway 505s*, each supplying 17,500 lb thrust, and has a gross weight of 316,000 lb.

● **The U.S. National Bureau of Standards** has published a report listing the most important developments in its research programme during 1959. Much of the material is concerned with the new technology of the space age. Special research has been conducted on the properties of materials at high temperatures; some of these studies deal with solid-state reactions in high-temperature alloys, refractory coatings for aircraft and missiles, and new cements for high-temperature strain gauges.

● **Antonov An-6** is the name of an improved version of the Antonov An-2 single-engine multipurpose biplane, developed under contract to Aeroflot. The An-6's altitude performance has been improved by the use of a TK-19 engine with turbo-compressor, giving a continuous rating of 1,050 h.p. at high altitude. Aeroflot intends to operate the An-6 on routes passing over mountainous areas, such as Tadzhikistan, where airports lie at altitudes of 6,600 to 9,800 ft.

● **Bell Helicopter Corporation** has begun testing its *Air Scooter*, a ground effect machine. This single-seat test vehicle is powered by a 12 h.p. two-stroke engine and can travel at up to 20 knots.

MUCH MORE ENERGY IN MUCH LESS SPACE



Bristol Aerojet process produces gas storage vessels of low weight and great strength—designed for maximum capacity in any given space

Bristol Aerojet, specialists in the design and manufacture of high tensile steel welded components, have developed a very advanced range of pressure vessels. The process produces gas storage vessels of exceptionally high storage capacity and low weight which operate with great reliability at high stress levels. These vessels are particularly suitable for aircraft aspirated systems where efficient operation is vital and where space restrictions demand optimum energy supply with minimum bulk. *Bristol Aerojet pressure vessels pack more energy into less space for less weight than any other type of gas storage bottle.*

Made of chrome molybdenum steel, the vessels are welded by the argon shielded tungsten arc process and heat treated to a minimum ultimate strength of 75 tons per sq in. All welds are examined several times during manufacture, both visually and radiographically.

Bristol Aerojet pressure vessels range from 10 to 2,000-cu-in capacity and when compared to forged vessels, show a weight saving of at least 5 lb per 500-cu-in and as much as 50%.

Bristol Aerojet Pressure Vessels chosen by Walter Kidde and RFD

RFD Co Ltd have chosen the Bristol Aerojet Type 3161 pressure vessel to inflate their 26-person reversible liferafts.

If you would like further information about Bristol Aerojet pressure vessels or high tensile steel welded components please write to:—

RFD/Liferaft

Bristol Aerojet Type 3161 Pressure Vessel

Design ultimate pressure	7,000 psi
Maximum inflation pressure	3,500 psi
Free gas volume	29.5 cu ft
Weight	7.75 lb
ARB approved	E 4804
Suitable for air or nitrogen	

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ROLLS-ROYCE BY-PASS JETS

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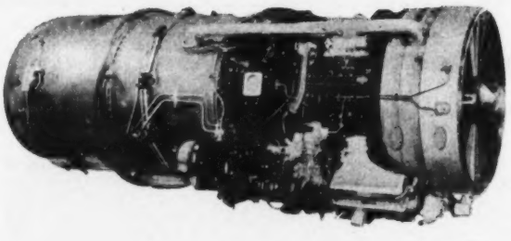
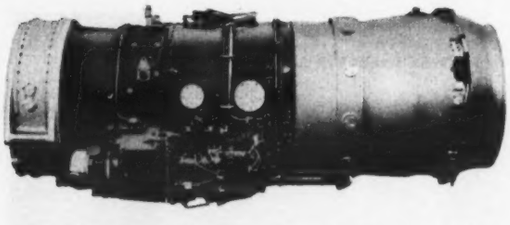
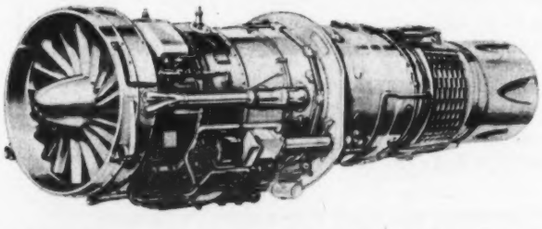


Conway by-pass jets will enter service this year in Boeing 707-420 and Douglas DC.8 jet airliners at 17,500 lb. guaranteed minimum thrust. The Civil Conway is being developed to powers ower 20,000 lb. thrust with improved fuel consumption and will power the Vickers VC.10.

THE BY-PASS PRINCIPLE PROVED BY THE CONWAY IS NOW GENERALLY ACCEPTED AS THE CORRECT FORMULA FOR JET TRANSPORTS



The RB. 141 of 14,300 lb. thrust will power later versions of the Sud Aviation Caravelle.



The RB. 163 of 10,100 lb. thrust has been chosen to power the Airco DH. 121.

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Notes from the Flight Deck

By *Albatross*, London

No general can lead his army to victory without knowing something about the enemy, and it is upon his intelligence service that he must rely to acquire the knowledge he needs.

The enemy in aviation is the accident, and it is only by having an efficient flight safety intelligence service that aircraft operators—civil and military alike—can hope to defeat the opponent.

A flight safety organization of this kind does exist today, and many pilots freely concede that it is to reading its *Pilots' Safety Exchange* and *Accident Prevention* bulletins that they owe their lives. It is the Flight Safety Foundation of New York, which was set up soon after the war to marshal disjointed and independent efforts of aircraft users into a sort of super flight safety intelligence service brandishing the motto "Share your experience."

In the past few years this non-profit-making organization has been trying to establish a foothold in Europe, and where it has managed to find firm ground it has found firm support for its work, even though the service it provides is based on American experience.

Since aviation is international, and increasing amounts of equipment become more and more common with an ever widening number of nations, this does not matter, but as Europe has its own particular problems, the service provided is by no means as comprehensive as it should be.

More than a year ago the extension of the Flight Safety Foundation or an organization capable of fulfilling similar functions for Europe was suggested in Britain. The aim was to establish an organization independent of any official government or international body to collect, collate and disseminate incident and accident reports, tips, trends and developments for the promotion of safety in the air, on the grounds that aviation safety transcends national and commercial rivalries, and that it safeguards the passenger, the profession and the aircraft industries alike. The names of those sharing their experiences were to be kept confidential.

But while there was enthusiastic support from a number of idealists, the proposals met with a certain amount of official opposition.

If such an organization were started in Britain, it was argued, it would be doomed to fail because of the suspicion Europeans held for anything British. By the same token, any European organization would be suspect by the British, even if its headquarters were established in traditionally neutral Switzerland.

In the past twelve months that attitude has changed considerably, and it was encouraging to hear KLM pleading for a wider exchange of safety information and experiences among aircraft users at the 10th Annual Seminar of the Flight Safety Foundation in Nice last October.

There has certainly been no lack of cooperation with the Cornell-Guggenheim Aviation Safety Center — the Foundation's sister organization devoted to applied safety research—which recently established a London office under Bosko Stanojlovic, the Yugoslav-born Wing Commander who retired from the RAF's Directorate of Flight Safety last year. And yet, when it comes to setting up a simple, central office through which information (vital to the flight deck as the exacting and expensive jet age gathers momentum) could be usefully filtered, there is an apparent reluctance to assist!

The situation in Europe today parallels almost precisely the situation that existed in the United States before the Flight Safety Foundation and the Cornell-Guggenheim Aviation Safety Center came on the scene. A few operators have established some mutual channels of communication to exchange data, while the military services issue technical orders and special bulletins, and government departments promulgate safety regulations and publish special notices on the subject. Proper interchange, however, is spasmodic; it lacks interest and it fails to span the enormous gaps that exist between users, and manufacturers. Besides, it is hampered by legal, political and commercial considerations. In a phrase, European aviation suffers from parochialism.

I can understand people not wanting to be dominated, and I can appreciate how sensitive they must be to the possibility of American domination. But with a Flight Safety Intelligence Service there's no need for it. Impartial and discreet, it would simply supply usefully analyzed experience to be remembered and applied as the occasion demands.

There is a desperate need for a proper information service of this nature today, preferably on a world wide basis. Outside America the field is clear; there are no toes to step on. But if the initiative is not taken soon, the passive parochial outlook will tighten its grip to affect the lives of many human beings and the integrity of the machines and technical amenities in which they put their trust.

Safety is no accident.

•

Talking of the parochial outlook, I am frequently dismayed by the inconsequential manner in which the authorities world wide look upon new ideas and equipment.

The *Black Hole* — that black void at the approach end of many a runway which robs a pilot of his depth perception at night—is a hazard pilots are having to contend with at a number of airports along the Far Eastern, African and South American routes, although two types of Visual Glide Path Indicator have been available for about three years.

It seems that the people responsible for the airfields in question cannot make up their minds about whether to have the Calvert or the Cummings system on two counts; firstly because the more influential aeronautical powers are divided on the question of which is the best—quite apart from pushing some system or other they thought up themselves—and secondly because of finance.

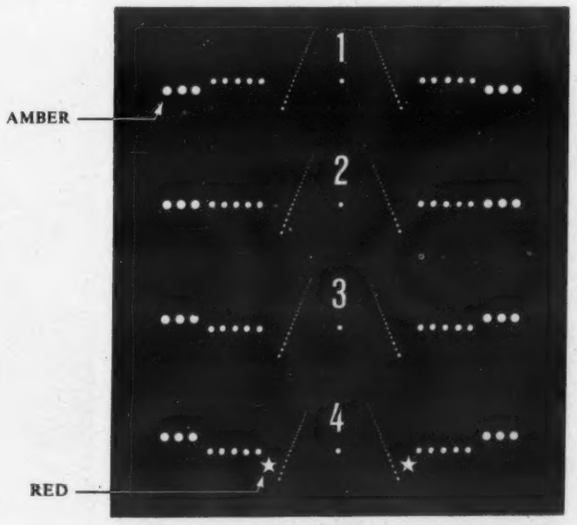
For preference I would like the Cummings system. It is direct and quite unambiguous. Furthermore it is the acme of simplicity: no prisms, lenses or anything special. Anyone with a grain of common sense and practical turn of mind could install one accurately with no more than the roughest of sketches and some spot-on measurements. As for cost, I doubt whether the poles, electric light bulbs, wire and labour needed would exceed £100.

For the price, the installation is likely to be primitive—but primitive or not I want it at those airfields which, apart from the approach lights and flare path, have no other visual references to the ground. I have wanted it ever since I read a description of the system; so have a lot of other pilots nightly taking a chance through the Black Hole.

On reflection, I wonder how many more years we'll have to wait?

The Cummings double-bar ground aid. The display appears in the same sense as the Artificial Horizon. The pilot flies to the amber outer bar.

1. Cross bar above amber bar—Fly down
2. On glide path.
3. Low—Fly up.
4. WARNING. Red lights. Below clearance gradient.



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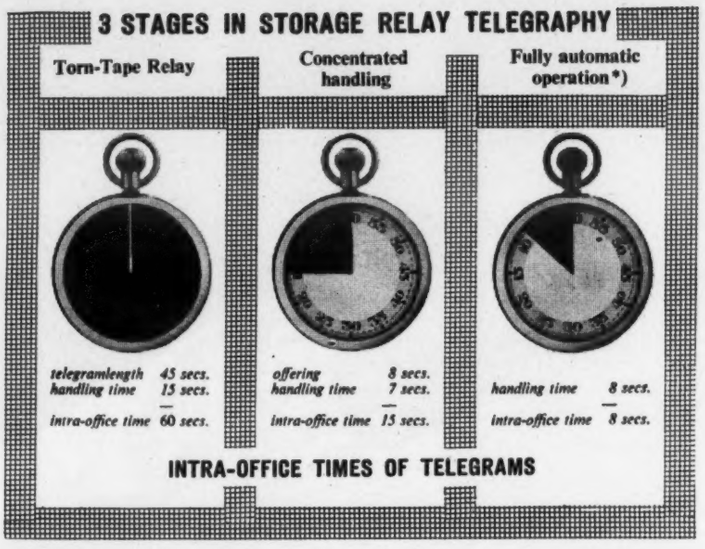
MIRAGE III
Mach 2
AVION OFFENSIF ET DEFENSIF
TOUT TEMPS
Générale Aéronautique Marcel Dassault
FRANCE



*** Last stage** towards automation:
Fully automatic operation!*)

Fully automatic operation can be applied to circuits where a fixed discipline for the composition of the telegrams can be relied on. This results in minimized intra-office times.

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N.V. Philips Telecommunicatie Industrie Hilversum, The Netherlands.

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Twin after-burning engines give the USAF T-38 Talon high performance with safety.

TO TRAIN SPACE AGE AIRMEN IN SUPERSONIC DEFENSE–NORTHROP'S T-38 TALON

Northrop is now producing the T-38 Talon for the U.S. Air Force Air Training Command. Pilots who have flown the T-38 agree that this is the plane in which the new generation of airmen can safely master the art of supersonic flight.

The twin jet T-38 is a member of the same low-cost and simplified-design family as Northrop's N-156F Freedom Fighter. Both incorporate similar performance characteristics and are powered by General Electric's J85 engines. Both reflect lower production costs, require only half the fuel to operate, and are far easier to maintain than aircaft of comparable performance. Both the T-38 trainer and the N-156F fighter are flying and ready for the Free World today.

NORTHROP INTERNATIONAL

A Division of **NORTHROP CORPORATION**, Beverly Hills, California

Northrop's Mach 2 Freedom Fighter–the N-156F–the modern, multi-purpose fighter.

The de Havilland Engine Company
have in production turbojet, turboshaft, piston
and rocket engines for a wide variety
of applications ranging from helicopters to
high-supersonic aircraft.

Electronics in Aviation and Industry

Synthetic Radar Training

"Your course is good—on the glide path—one mile to touchdown." The deliberate voice of the talk-down director transmitting instructions for a ground controlled approach (GCA) is the product of training and experience. To carry out an approach and landing under conditions of bad weather and visibility, two widely different skills are required. The pilot on board the aircraft must possess a high degree of instrument flying ability to make a prompt and accurate response to his instructions, while on the ground the controller is faced with the task of rapidly interpreting the radar picture of the aircraft and deciding on the corrections to be made to ensure a safe landing.

This interpretation of the radar data calls for both anticipation and forbearance. At low altitudes, a deviation of the aircraft from the desired course requires immediate correction; at the same time a rapid stream of instructions for minor alterations of course and glide path will end in confusion and possible disaster. Allowances must be made for the time lag between the transmission of the instruction and the indication of the change of flight path on the radar screen. This also means that consideration must be given to the type and performance of the aircraft on which the GCA is being carried out.

The difficulties in attaining this level of training and experience are patently obvious. The controller must learn the technique through repetition, but the source of that experience is difficult to achieve. On the one hand, the use of a target aircraft flying practice approaches is uneconomic both in terms of cost and time, while on the other, a fully laden commercial aircraft making an approach in conditions of deteriorating visibility is not the ideal target to be left to the attention of the unfledged controller.

These two possibilities represent the extremes of the case, but clearly illustrate the difficulties and expense of training personnel in the operational use and interpretation of radar information. The problem is not confined merely to the training of GCA operators, but extends throughout the whole range of both military and civilian radar applications. The acquisition of a high degree of skill and experience by radar operators and controllers is vital both to the safety of air traffic and to the interests of national defence.

Faced with similar problems of expense and time in the training and conversion of aircrew, many airline companies and air forces have adopted the aircraft simulator as a means of developing experience with the maximum of thoroughness and safety. The essence of any simulated training is realism, and present day techniques in simulator design are so advanced in this respect that instrument flying tests carried out in an aircraft simulator are now accepted as a measure of individual ability.

To provide similar facilities for the training of radar personnel, *Solartron Radar Simulators Ltd.*, of Farnborough, Hampshire has developed a radar simulator system which can be applied to meet the training requirements of any radar installation. The whole of the equipment required to reproduce any particular application can be built up from standard modular (building-brick) elements. Under the heading of civil radar these applications cover Air Traffic Control and Airport Control, and the system can be used for the evaluation of new methods and procedures under development. Military applications include early warning radar, ground controlled interception, fire control and tactical training. Widely differing types of radar such as air surveillance/search, height finders, ground controlled approach and Lock-Follow equipment, can all be simulated with this system.

The basic radar simulator

By use of the building-brick concept the design of the simulator system permits almost unlimited expansion and elaboration. The same basic units, used in greater numbers, may be used to build up more elaborate systems. These may range from the simulation of a greater number of target aircraft, to tactical training systems with several moving radar bases, each giving its own viewpoint of the common situation. In its simplest form, however, a radar simulator consists of a number of "targets" and a central equipment representing the appropriate radar installation. The pilot of the "target" sits at an individual control panel and directs the course of his "aircraft." Electronic computers continuously follow the effects of these control movements and keep an accurate track of the moving target. As the beam of the simulated radar aerial rotates, echo-responses appear on the radar screens at the computed range and bearing of each target.

In the Solartron system the basic radar simulator provides the necessary material to simulate a typical "search" type radar with either aircraft or ship targets.

a) Target control and computing units, one set being required for each target. This equipment consists of the target control unit, target track unit, ranging unit and radar unit.

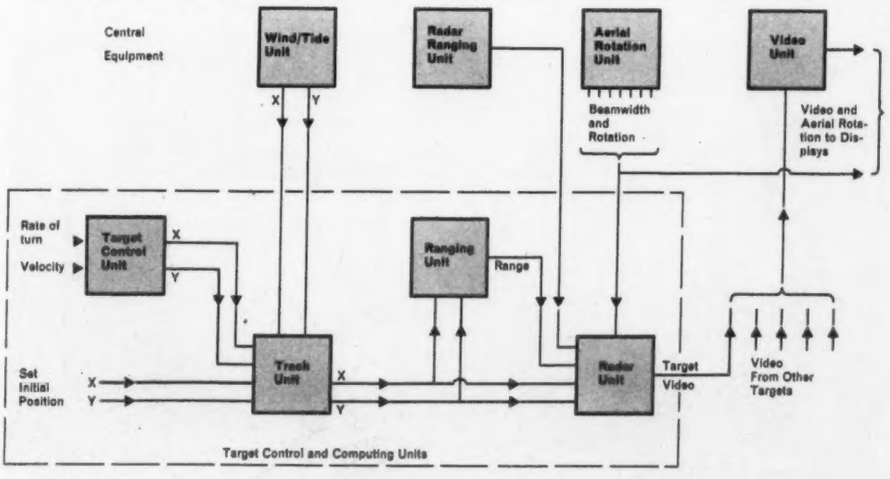
b) The central equipment, comprising wind/tide unit, radar ranging unit, aerial rotation unit, video unit and power supplies.

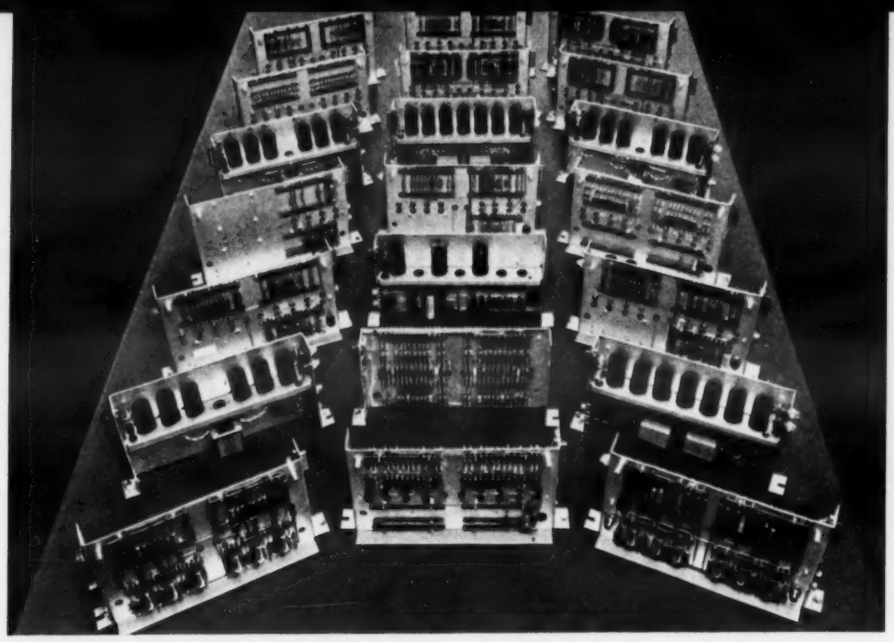
It should be noted that no provision is made here for display equipment as this is assumed to be already in service with the user.

Target control and computing units

One set of the units listed in para (a) above is required to simulate each independent target. Each target control unit is manned by a separate

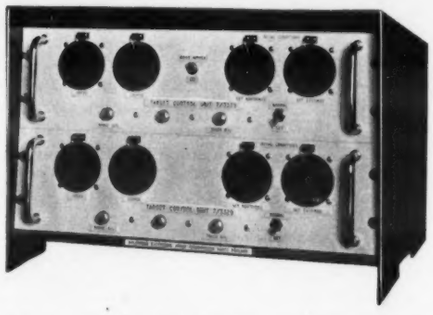
A simplified block diagram of the radar simulator. The broken line encloses the elements of the Target Control unit while the Central Equipment is shown above.





A selection of the basic electronic sub-units showing how the same "Standard Chassis" is employed for various applications.

operator or "pilot," and the controls on the unit enable the operator to simulate the movements of an actual target aircraft. At the beginning of the exercise the target's starting position and height are fed into the unit by means of setting dials, and thereafter the course, speed, and rate of climb and dive are adjusted by the operator to simulate an aircraft in flight. When the original settings have been made and the unit started, the computers continuously plot the position of the target in terms of its X and Y cartesian coordinates, or in other words, its "Northings" and "Eastings." Starting from the initial position, this is continuously brought up to date by the integrated effects of the control settings and alterations. Additional elements derive the "Z" (height) coordinate, thereby fixing the target in all three dimensions. These positional coordinates are then converted to radar parameters of range, bearing and elevation and passed to the central unit. The number of targets required for any particular exercise can be obtained by the addition of the appropriate number of control units, and each target retains its individual freedom of manoeuvre.



A dual target control unit which enables two targets to be directed at the same time. The left hand dials adjust the course and speed of the synthetic target, while the right hand are for setting its geographical position at the commencement of the exercise.

The central equipment

Together with the target data produced by the target control and computing units, further information has to be incorporated in the display to provide the necessary realism. This information is produced by the units forming the Central Equipment and is common to all the targets. The wind/tide unit fulfils either aerial or marine applications and by converting wind speed and direction values into X and Y coordinate changes it introduces the effect of drift into the target's movement; or in the case of a marine target the effects of tides and currents. The aerial rotation unit simulates the speed of rotation of the aerial head and also the radar beam width, thereby producing the necessary azimuth information on the display. The last unit of the central equipment, the video unit, assembles the video outputs from all the target control units and distributes them to the display.

Simulator units being demonstrated to officers of the Federal German Air Force. At the right of the table is a specially designed equipment for training GCA operators.

Simulator application

Commencing with these two basic units of the simulator, the installation can be built up to match the user's particular training requirements. The "unit" principle of construction readily permits increase in the number of targets or the number and types of radars. By selection of the units, equipment can be provided to meet the training requirements of civil, military and marine radar users. In civil air surveillance and approach control training, the use of a simulator enables training to be carried out by operating personnel on duty at off-peak periods. Situations can be set up which a responsible operator should be prepared to encounter but which arise only rarely in training with live targets. A further advantage of the flexibility of the system is that synthetic targets can be added to the normal live display to represent high density traffic conditions. By these means, future methods of control can be evaluated, and problems solved in advance under realistic conditions.

Similar advantages exist in the use of simulators for military training. A continuous programme of full scale exercises can be provided without the actual employment of aircraft. The synthetic targets can be divided into two forces, each under its respective force commander, to enable tactical evaluations to be carried out. A point of interest in this connection is that tactical problems can be studied without danger of a breach of security, as the data remain within the equipment, and no traceable radio transmission is made.

For marine applications, including anti-collision training, special "own ship" units enable the simulated radar viewpoint to move. This presents the radar picture as it would be seen from a moving vessel, with the position of all other echoes shown relative to "own ship."

System realism

The essential requirement for successful training by simulated means is reality. In this system, the appearance of the synthetic target on the normal display provides this reality in full measure. Live target echoes can be intercepted by synthetic aircraft, or additional simulated aircraft fitted into an existing traffic pattern. To provide the training staff with the fullest range of equipment to ensure the presentation of real life conditions in training exercises, Solartron has also designed a number of additional units which can be introduced into the system as desired. These units will simulate electronic countermeasures equipment such as "noise-jammers" and "window" (reflecting metal strips). For marine training, similar units can provide permanent echoes of coastlines, buoys and moored vessels as seen by radar.

With this ability to produce realistic simulators of any radar phenomena and any type of radar equipment, the scope of future radar training is limited only by the ingenuity of the directing staff. To learn by experience has always been regarded as the classic method of tuition. With today's costly aircraft and weapons it is often impracticable to give radar operators the opportunity of seeing on their screens a dress rehearsal of a situation which they may have to interpret under the stress of an emergency. To learn by experience under present day conditions it would appear that the simulator is the only practical answer. ⟷

Airport Surface Detection Equipment gives the operator a bird's eye view of New York's Idlewild airport. The dots at the edge of the runway are runway lights and indicate the high resolution of the equipment. In the lower picture three aircraft can be seen holding at the runway intersection while a fourth is landing. The successive images of the aircraft are due to the movement of the aircraft and the rotation of the antenna.

A New Aid to the Air Traffic Controller

Airport Surface Detection Equipment

By A. Robertson, Airborne Instruments Laboratory, Long Island, N. Y.

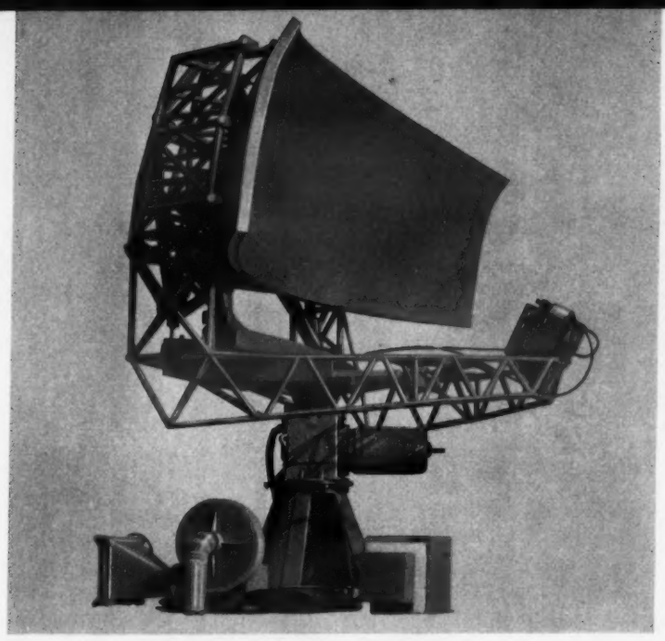
One of the latest radar and electronic aids available to the traffic controller in the United States is known as ASDE—Airport Surface Detection Equipment.*

This radar system has been under development for several years. The first experimental unit was built for the U.S. Air Force by a commercial contractor shortly after World War II. The present ASDE is the outgrowth of a long-term program sponsored by the United States Air Force and the United States Air Navigation Development Board, and implemented by Airborne Instruments Laboratory, Melville, New York. An experimental model of ASDE has been tested and evaluated at several different airports by FAA and the Air Force. The final model, incorporating improvements dictated by these tests, has been installed in the control tower at New York International Airport, where it is now in commissioned operation. Production equipments from Airborne Instruments Laboratory are scheduled for early installation at: New York Newark, Boston, Washington, Cleveland, Chicago, Los Angeles, San Francisco and Seattle.

System Description

The ASDE radar operates in the K (SHF) band of frequencies at approximately 24,000 Mc/s. The antenna, enclosed in a plastic spherical radome, is mounted atop the control tower or other suitable elevated location where it can scan the entire surface of the airport. The antenna system consists of a horn feed, with provision for selecting

* London Airport has been equipped with a Q-band Airfield Surface Movement Indicator (ASMI) constructed by Decca Radar Ltd. since 1955; see *Interavia* No. 2, 1956. — Editors



The reflector, feed horn and pedestal of the ASDE antenna. The 4 by 12 foot reflector produces a beam which is shaped to give coverage to 25 degrees below the horizon. The feed horn can be set to give either vertical or circular polarization for improved performance in precipitation.

circular polarization when required, a double-curved solid surface reflector of approximately 4 ft by 12 ft aperture, and a pedestal and drive mechanism for rotating the antenna at 60 r.p.m.

The azimuth beamwidth resulting from this antenna configuration is 15 minutes of arc (0.25 degrees), subtending about 10 feet at a distance of one-half mile. The vertical beamwidth is 1.0 degree, cosecanted downward to -25.0 degrees at the half-power point.

Transmitter peak power is 50 kilowatts. Pulse length is 20 milli-microseconds, representing about 10 feet in range. The repetition frequency of 14,400 p.p.s. insures some 8–10 hits per beamwidth at 60 r.p.m.

The receiver of the ASDE radar features distributed amplifier techniques to achieve in a simple and reliable manner the 50 megacycle bandwidth necessary to take full advantage of the highly detailed information gathered by the R.F. system.

The indicator console, containing the PPI and its associated sweep and deflection circuits and power supplies, is designed for use in the control tower or in the radar approach control center (or both), and may be located as much as 6,000 feet from the radar. Data transmission is accomplished over coaxial cable.

The ASDE operates on 50/60 cycle station power. The ASDE PPI presents a map-like picture of the airport. There is no need for a map overlay or video mapping technique, since the picture presented by the radar itself is of sufficient resolution to depict all useful information.

For a "close-up" view of an area of particular interest, a shorter radar sweep range may be selected, resulting in still more details. It is also possible to off-center the sweep origin up to one diameter in any direction by a single control on the console.

Operational Benefits

This highly detailed information provides obvious benefits to the ground and local controllers in the tower during instrument conditions. Less obvious, but perhaps even more useful, information may be provided by an ASDE console adjacent to the approach controller in the IFR room. Constant and immediate information on runway occupancy time of landing and departing traffic relieves the controllers of any uncertainty about surface traffic movements and results in reduction of the time between successive approaches and take-offs.

During periods of restricted visibility or when the ceiling is at or near the authorized minimum, runways and taxi strips are often not discernible from the tower cab. During these conditions, without ASDE radar information, aircraft taxiing between terminal areas and hangars, taxiing to pre-flight run-up areas, or taxiing out for take-off can become involved in bottlenecks at critical points to the extent that all traffic must stop while ground service personnel untangle the tie-up. The use of ASDE makes it possible for one responsible operator to see the entire airport situation, anticipate problems, and avoid bottlenecks by directing traffic in such a way as to keep it flowing smoothly.

Thus the information provided by ASDE reduces delays to arriving and departing aircraft, reduces idling time on the ground, and reduces collision risks on the ground. It also reduces the number and duration of R/T contacts between controller and pilot since the controller does not need to query every pilot to determine whether he is clear of an active runway, has started his take-off roll, or has executed whatever other manoeuvre traffic control has requested.

ASDE radar also is most helpful in "leading" pilots not familiar with taxi and runway configurations of the airport.

Observation and actual control of aircraft and other vehicles during periods of reduced visibility reveal that the volume of surface traffic that can be controlled by an individual controller using the ASDE radar display depends on whether conditions are really "zero-zero," or whether the pilot or vehicle driver has some visual reference to runway and taxiway markings. Generally, experience indicates that when forward visibility is less than 50 feet, three aircraft are the most that can be furnished full ASDE control at a time, since operation under these conditions requires constant R/T communication and close observation of the radar scope.

If the controller needs to monitor only the movement of surface traffic and furnish ASDE control occasionally, about eight aircraft can be directed at one time.

Experience shows that a controller can direct an aircraft or vehicle at a speed of about 25 m.p.h. and keep within 10 or 15 feet of the runway centerline. Separation distances between vehicles or aircraft can be safely estimated to within about 30 feet.

The ASDE radar mounted within a radome on top of the control tower at Idlewild International Airport, New York. The enclosed antenna rotates at 60 rpm, giving the air traffic controllers a complete picture of traffic movements on the airport.

Conclusions

As a result of the operational use of the ASDE, the following conclusions can be reached:

1. It provides sufficient information to controllers to guide pilots or drivers along a desired course on runways and wide taxi strips.
2. It provides the pilot or driver with information to aid him in turning accurately to taxi strips, runways, or ramp areas.
3. It provides safe separation between converging aircraft or vehicles operating on the airport.
4. It views portions of the airport that are not now discernible from the tower cab because of obstructions or low visibility.
5. The use of the equipment as a ground control aid has been satisfactory under all conditions of weather.
6. ASDE display located adjacent to the approach controller has proved to be very beneficial.
7. The use of ASDE results in significant savings of time between take-offs, safer operations, and reductions in R/T procedures. →→

What's New in Electronics?

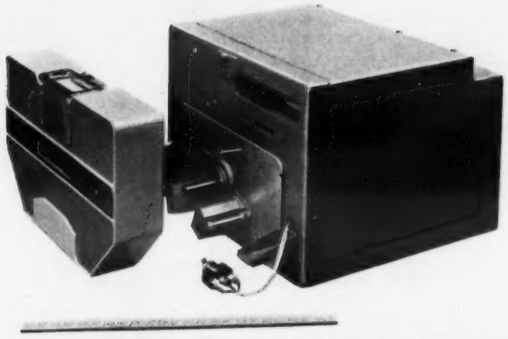
● **Ekco Electronics Ltd., Southend on Sea, England** produce this Type E190 light-weight weather radar which is to be installed in the new BEA *Vanguards*. Transistorized circuitry has made extensive savings possible in both size and weight while offering considerable advantages in reliability and reduced power consumption. The 24 inch (61 cm) scanner illustrated here is fitted with line of sight stabilization and scans over the range of ± 90° in azimuth at 40 scans (20 cycles) per minute. This high scan rate offers a better display fidelity than the continuously rotating system and eliminates display distortions due to elapsed time errors. Beam shaping vanes are fitted to the reflector to modify the normal pencil shaped beam to a cosec^2 beam for ground mapping.

● **Sperry Gyroscope Co., Great Neck, N.Y.** has developed a daylight indicator for use with its APN-59 radar to enable pilots to see navigation and storm information clearly on the radar screen despite bright sunlight or glare. In addition, the cathode ray tube used in the new indicator holds target information longer, making the scope easier to read.

● **Leach Corporation, Compton, Calif.** is the designer of this miniature airborne tape recording system, which is being developed for space, air and industrial applications. The 28 channel recording device is cylindrical in form with a diameter of 6¼ inches and length of 6¼ inches. Its weight is less than 10 pounds and it was designed for data recording on recoverable missiles, satellites and rocket sleds. The tape speed is 30 inches per second and its capacity provides 30 seconds of recording. Twenty-six different channels of information can be recorded while two tracks are used for recording timing and event signals. In the righthand illustration the unit is shown open with the two 24oz Leach recorders which form the heart of the device removed. The lefthand illustration shows the fully encapsulated unit alongside a standard voltmeter for size comparison.

● **Hughes Aircraft Company, Culver City, Calif.** displays the Hughes airborne armament system in front of a Convair F-102A all-weather interceptor. The photograph is illustrative of the quantity of electronic equipment in terms of both size and weight, which is essential on board a modern all-weather aircraft. In the foreground is the radar search equipment and head, backed by an array of transmitter/receivers and computers.

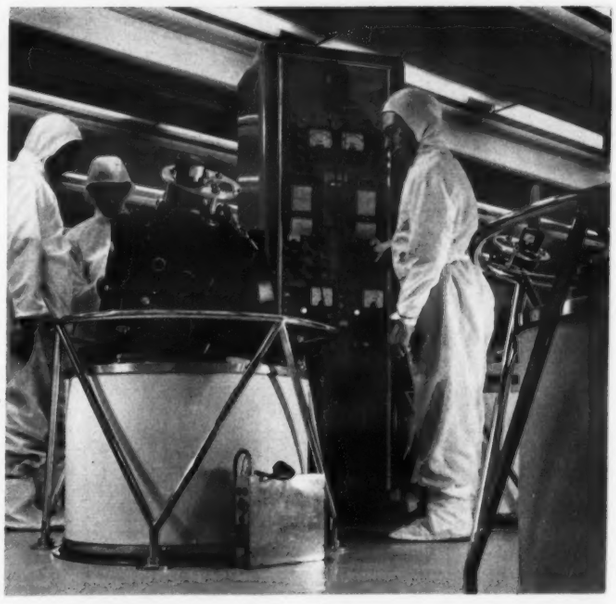
● **Minneapolis-Honeywell Regulator Co., Boston, Mass.** is commencing commercial production of precision test equipment that will enable calibration of gyroscope instruments to be undertaken in the field. The three units illustrated are from left to right: a regulated power supply, a rate table and a calibrator to provide precise measurements of system performance. The equipment will fulfil an important need as with the growing number of complex gyro instruments on board the modern Service aircraft it has become increasingly necessary to test these units in the field. The rate table is fitted with a mounting fixture that will accommodate a wide variety of gyro units and can be adapted for testing either complete gyro units or individual gyros.



● **Autonetics Division, North American Aviation, Downey, Calif.** has sold over 6,000 units of the *Nadar 8* airborne recorder illustrated here. Two hours information can be recorded on a 1,000 foot tape, and the recorder will accept both electrical impulse and voice signals. The tape cassette is completely self-contained and can be easily changed. A footage indicator is built, into the cassette.

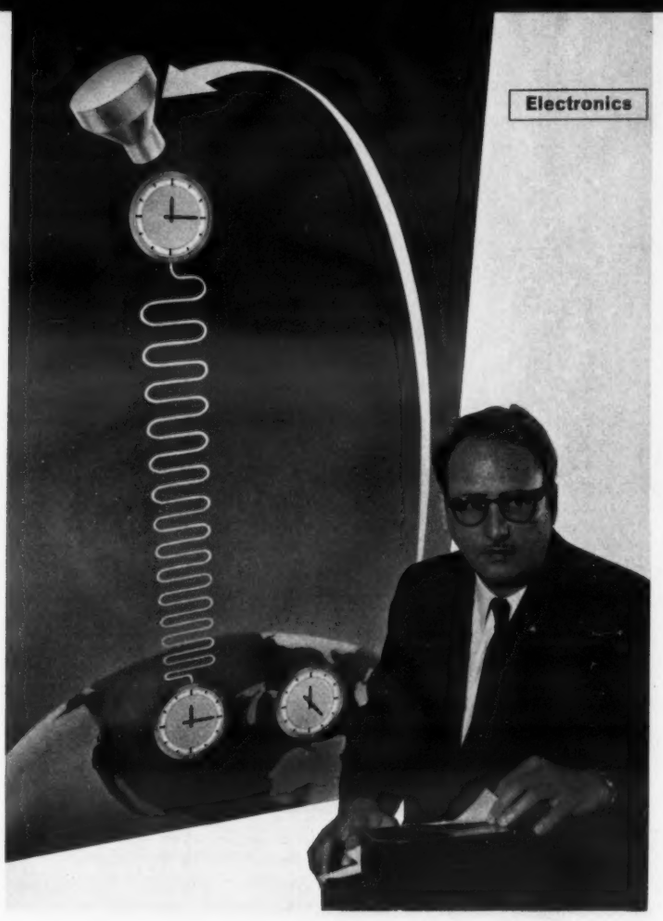
◄ ● **IBM Data Processing Division, White Plains, N.Y.** has established a new automated assembly system which turns out computer transistors at a rate of 1,800 per hour. In the photograph the transistors are undergoing final inspection and the contents of the racks in front of the operator represent eleven minutes production.

● **Ferranti Ltd., Edinburgh, Scotland,** has recently opened a new laboratory for the production of high-precision gyroscopes and accelerometers for inertial navigation systems. The engineers seen here are wearing special lint-free protective clothing to ensure that dust particles are not carried into the specially air-conditioned atmosphere of the new laboratory. ►



● **Sylvania Electric Products Inc., Needham, Mass.** is responsible for the design, production and installation of the data processing phase of the Ballistic Missile Early Warning System (BMEWS). The electronic observer in the system is the first three dimensional device of its kind, estimating target azimuth as well as range and radial velocity. This device is called the Detection Radar Data Take-off subsystem (DRDTO). The DRDTO is a complex of special-purpose computers that analyzes BMEWS radar echoes and extraneous "noise" returns and detects from these the presence of potential missiles. In the photo E. J. Vigneron, General Manager of the Data System Operations, is shown examining an element card from one of the logic boards of the DRDTO.

Time Will Tell



Dr. Harold Lyons, head of the atomic physics department at Hughes Aircraft Company and inventor of the atomic clock, is seen with a display illustrating the principles of the proposed NASA experiment.

Recent years have seen the opening of a new field in the science and techniques of electronics. As distinct from the use of free electrons emitted by a hot filament in a vacuum tube, the new science employs electrons which are still bound to an atom or molecule. This new technique has become known as solid-state or molecular electronics, and the captive electrons offer many new properties as compared to free electrons.

One particular feature of the behaviour of these bound electrons is that they can only exist in states or energy levels in which they can store radiant energy. A transition between these states is accompanied by the absorption or emission of energy at frequencies varying from radio to optical ranges. The use of this characteristic in electronic techniques is enhanced by the fact that as atomic elements are manufactured by nature, they are all exactly alike and do not exhibit any of the variations in behaviour which occur with fabricated high-frequency components. This uniformity of performance makes the use of atomic elements particularly attractive in the millimetric and higher frequency bands. Elements can be used which provide all the circuit elements of resistance, inductance and capacitance encountered in ordinary electronics.

Research into the characteristics of atomic circuit elements has led to the development of high sensitivity, low noise amplification systems. These systems, known as MASERs (Microwave Amplification by Stimulated Emission of Radiation), have been developed in two distinct types, those using atomic or molecular beams and those using solids. The beam type maser forms an extremely stable oscillator, while the solid type sare most satisfactory as amplifiers.

The operation of a beam maser is dependent upon the ability of an atomic system like a molecule to exist in any of a series of energy levels or states. The molecule can make transitions between these states, absorbing energy in going to a higher level and emitting it when going to a lower. These transitions can be caused by using an electromagnetic wave to excite the molecule by radiation. The wave will either lose energy to the molecule by absorption or gain energy from it by emission. Whether absorption or emission occurs is dependent upon the molecule being in the upper or lower state of energy level or content. Normally a net absorption occurs as more molecules are in the lower than the higher energy levels.

An illustration of this operation is given by the working of an ammonia beam maser. To obtain a beam of ammonia molecules, liquid ammonia is vaporized and sprayed as a jet into a vacuum chamber. This vacuum is required to prevent the beam being scattered by air molecules. The beam then passes through an electrode structure which sets up an intense, non-uniform electric field. The purpose of this is to separate the high from the low energy molecules, as a net emission of power from the beam is desired. The low energy or absorbing molecules are deflected out of the beam while the high energy molecules are directed into a microwave cavity. Thermal radiation within the cavity then initiates the emitting transitions by a process of stimulated emission. The ammonia molecules then radiate their energy at a frequency of about 23,870 Mc/s. The microwave cavity is tuned to resonate at the same frequency so that a continuous oscillation is set up in the cavity.

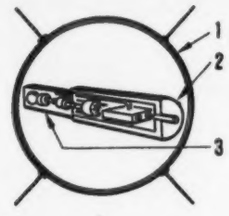
The existence of the beam maser has made it possible to design equipment to conduct a proposed experiment which would provide a searching check of both general and special relativity theories. The particular experiment has been made feasible by man's recently acquired ability to place a satellite in a space orbit around the earth.

Recently in the United States the National Aeronautics and Space Administration gave Hughes Aircraft Company, Calif., a contract for the development of an atomic clock weighing about 30 pounds and suitable for use in a satellite. The accuracy of this clock would be of the order of three parts in 10^{11} or one second in 1,000 years. Its purpose would be to check both the general and special theory of relativity which show that clocks should undergo both motional and gravitational time changes, as the satellite would be in high speed motion in a weaker gravitational field than that at the surface of the earth.

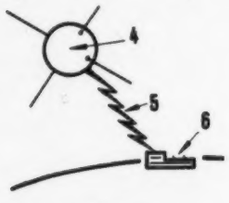
The ammonia beam maser will be the heart of this atomic clock, and its operation is similar to the general principles of all types of atomic clock. A vibrating atom or molecule is used to give the constant ticking of the clock in the same way that the oscillations of the balance wheel are used in a watch mechanism.

The maser clock uses the vibrations of ammonia molecules. These look like pyramids having three hydrogen atoms at the base with a nitrogen atom at the apex. The nitrogen atom moves up and down 24,000 million times per second, and these vibrations are the ticks of the maser clock. Because of the vibrations, the molecule emits the ticks as radio waves which are available as output power from the maser oscillation. It is these radio waves which ultimately run the maser clock by driving a frequency divider which synchronizes a low frequency clock of the quartz crystal type with the high

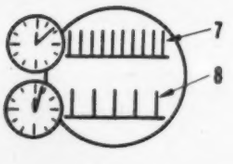
Heart of the atomic clock is this small tubular component which houses the stream of ammonia molecules. Total weight of the atomic clock will be about 30 pounds and it will have an operating life of 500 hours.



1. Satellite
2. Atomic clock
3. Ammonia beam generator. Ammonia "ticks" at about 24,000 million times per second.

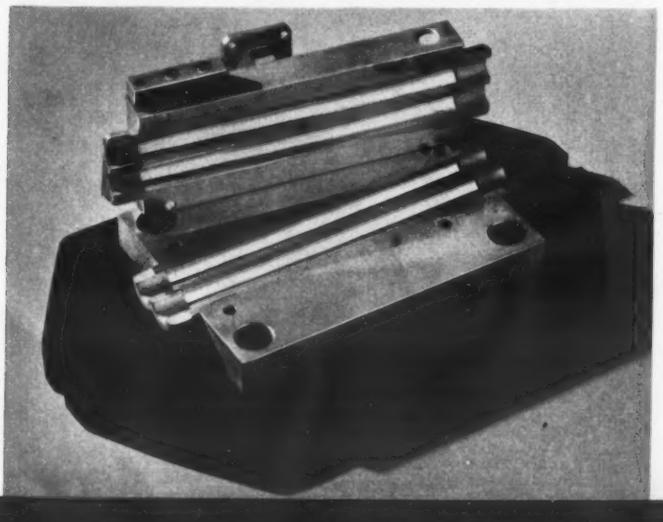


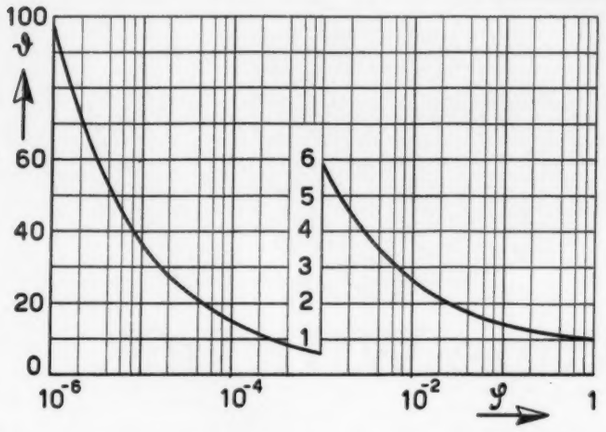
4. Satellite-borne atomic clock
5. Radio waves and "time ticks" down from satellite
6. Ground clock



7. Ground clock's ticks
8. Satellite-borne clock's ticks

A special feature of the atomic clock is the twin cavity system illustrated here. Made of low-temperature-expansion alloy, the twin cavity is much less sensitive to temperature changes than a single cavity system, resulting in a far more accurate maser.





Relativistic time dilatation ϑ ("Earth time" to "Vehicle time") for various speed conditions ($\varphi = 1 - v/c$) from the calculations of Professor J. Ackeret (cf. *Interavia* No. 12, 1956).
The space clock runs slower, assuming the space vehicle to be travelling at 99% of the speed of light (therefore $\vartheta = 0.01$ and $\varphi = 2.66$) and the ground clock and vehicle clock to have been synchronized at 12 noon. When 2.66 earth hours have elapsed, and the earth clock shows 14.40 hours, the hands on the space clock will have moved forward only one hour and will indicate 13.00 hrs. At 99.99% of the speed of light the space clock hands will move forward roughly one hour for every fifteen earth hours ($\varphi = 0.0001$; $\vartheta = 15$).

frequency (24,000 Mc/s) maser. The frequency divider circuit is analogous to the gearing which is used to drive the hour hand of a normal clock 60 times more slowly than the minute hand.

When the atomic clock is available it is anticipated that NASA will make further plans leading to the launching and tracking of the clock in orbit. When these preparations are completed it will then be possible to embark on the series of intended experiments.

The satellite-borne clock, travelling at about 18,000 m.p.h., will periodically transmit its time reading by radio to a ground station, where the time will be compared to a similar maser clock at the ground station. According to the general relativity theory the satellite clock should run slow in comparison to the ground clock in orbits below 2,000 miles and fast above 2,000 miles. This is because effects of motion predominate below 2,000 miles and effects of gravity predominate above. The effects are of opposite sign and cancel each other at 2,000 miles; that is, at this altitude the satellite and ground clocks agree. At a height of 8,000 miles for example, the two clocks should differ by about 1 second in 60 years. By means of flight at various heights both special and general relativity theory can be checked quantitatively. Special relativity theory shows that a moving clock runs slow giving rise to a motional time dilatation which is very small for low velocities but which slows a clock down to zero at the velocity of light or radio waves. General relativity theory shows in addition that a clock runs at a lower rate in a higher gravitational field. Since the satellite clock will be in high speed motion in a weaker gravitational field relative to a ground clock, it will run at a rate determined by both motional and gravitational time shifts.

The existence of a satellite-borne maser clock will open the field for further experiments to extend our understanding of nature. By setting up a second ground station and measuring the time taken by the signals to reach the two stations from the satellite it would be possible to calculate the distance between the ground stations by triangulation in terms of the known velocity of radio waves. Such measurements would give the exact geometric shape of the earth and could be made over inaccessible regions of the earth's surface. Similarly the experiment can be reversed and the velocity of the waves measured in terms of the distance between the two ground stations. By repeating these measurements in different directions in space over paths of thousands of miles, it would be possible to determine whether space is isotropic, that is, whether it is the same in all directions.

The existence of the beam maser, with its high degree offre quency stability, provides the most accurate timing instrument that man has possessed throughout his development. It offers new means to explore the mysteries of space and to confirm or destroy theories which are at present entirely unproven. Truly one can say—time will tell. ⟶

International Cooperation in Airspace Control

by L. Piollet, L.M.T., Paris

A new link has been forged, like many others in the past, by aviation. And, when so many factors of discord divide the peoples of the world, such evidence of collaboration and solidarity comes as a welcome change.

Years ago the U.S. aeronautical authorities set themselves the aim of developing a unique air navigation system as the essential preliminary to the complete and efficient control of airspace and its users.

To record the stages of this achievement is to note the difficulties which have been successively encountered and overcome. Users of airspace are many and varied all over the world, and this is particularly so in the United States: pilots of the Air Force and Navy, airlines and air work companies, each category has, until recently, had its own equipment, its own methods and its own pet theories.

It was the U.S. Navy which, as early as 1945, first defined the system which found favour in the eyes of all. Initially, the only claim of this air navigation system was that it enabled carrier-based aircraft to rejoin their vessel with certainty. A radio beacon installed on the carrier transmitted its bearing and range to every pilot. The latter information could be received by fifty aircraft simultaneously up to a distance of 100 nautical miles from the aircraft carrier. As polar coordinates were used, no special maps were required, and the system's simplicity made it universally acceptable.

The method aroused the interest of the USAF, which set its technicians to work with the Navy to study the possibilities of adapting the system to Air Force requirements. The result of this joint study, which was, of course, associated with the work of the ITT, originator of the technique, was TACAN (DMET), which was the standard air navigation system for the U.S. armed forces as early as 1952. At this first stage of standardization the system had to comply with USAF requirements by doubling its range and the number of aircraft which could receive the range signals; here it had the chance to prove its basic quality, that of perfect adaptability.

The third stage consisted in winning acceptance for the system in civil aviation circles in the USA, and here the authorities encountered a serious obstacle. While the armed services were developing TACAN as a classified project, a vast network of VOR omnidirectional radio beacons was being installed for civil aviation, whose rapid rate of development did not permit of delay in the creation of navigation aids. In view of all the money which had already been spent on VOR, there could be no question of scrapping either the ground equipment or the airborne instrumentation. But here again, thanks to TACAN's flexibility and adaptability, a satisfactory solution was found, and a system known as VORTAC was evolved, combining the bearing supplied by VOR with the range derived from TACAN.

To satisfy the joint needs of both its old and new customers, VORTAC could be adapted to meet a variety of requirements owing to its simplicity and flexibility. These qualities have enabled it to be used in conjunction with ILS and Data Link air traffic control procedures. The combined air navigation system was invaluable in the unification of Air Traffic Control services in the USA early in 1959 under the auspices of the Federal Aviation Agency. In the not too distant future the placing in orbit of three relay satellites should make it possible to use VORTAC over any range. But VORTAC has already served the interests of international cooperation without awaiting these developments; for the cold war and the installation of USAF bases on the free world's bastions inevitably led to the progressive adoption of the TACAN system. Adopted by NATO in 1955, it is now being set up in the organization's fifteen member States.

In 1959, then, the situation in Europe was similar to that in the USA in 1956. The armed services in Europe had a DMET network in course of completion, and the civil VOR network was already at an advanced stage of development, when ICAO, at its February, 1959 session, voted for the adoption of VOR, supplemented by DMET, as standard equipment until 1975.

The economic arguments which dictated the adoption of VORTAC in the United States were equally applicable in the European NATO States, and led to a joint study by the civil and military authorities of a VOR/DME range/bearing network to meet all their requirements.

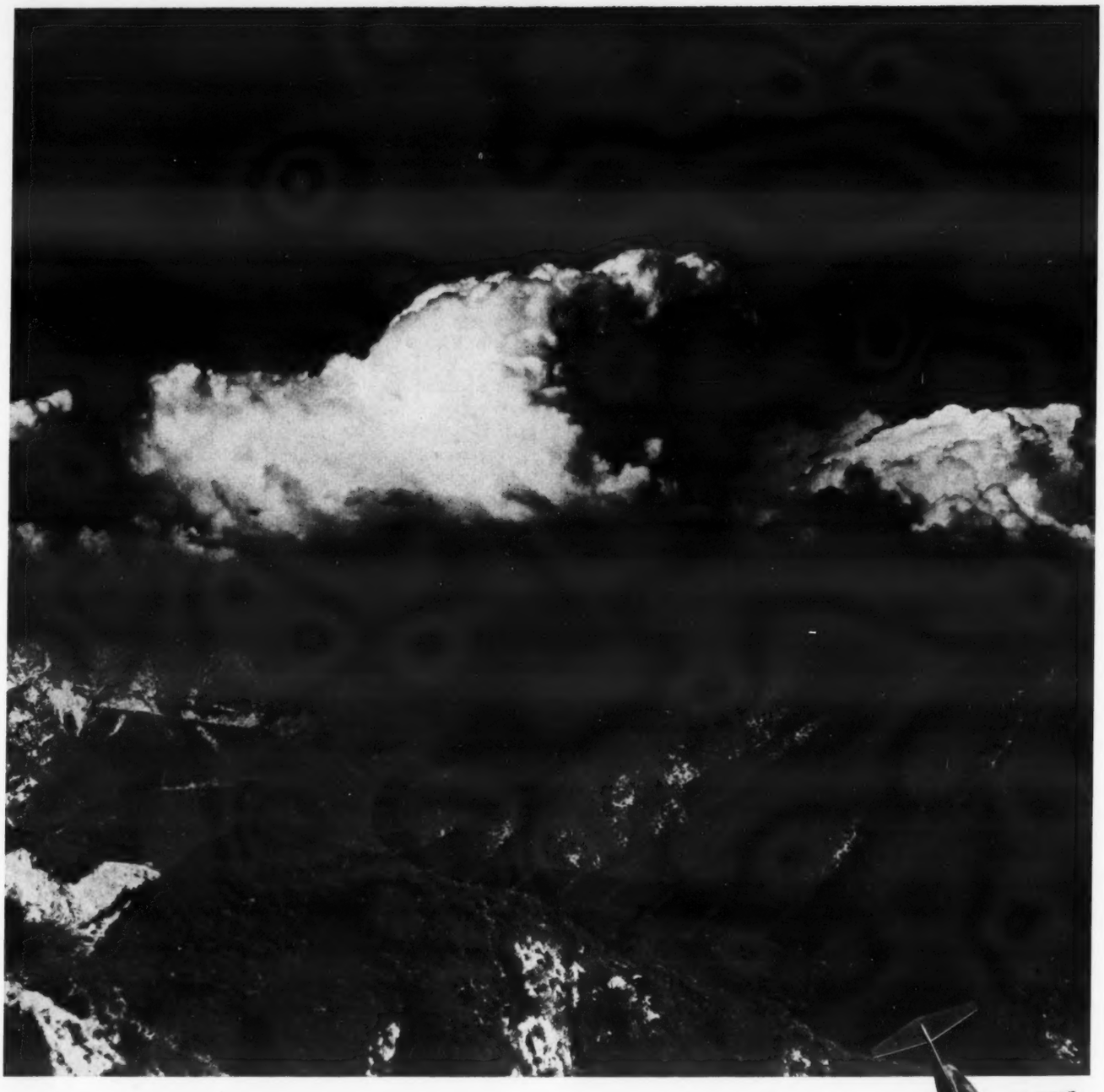
The Coordination Committee for European Airspace studied the question during the last quarter of 1959, and the exemplary cooperation of all its delegates resulted in some highly significant conclusions.

By comparing the demands of the civil authorities with those of the TACAN military network, the Coordination Committee for European Airspace noted that 50 percent of requirements could be met out of military resources and 25 percent simply by adding DME to existing VOR stations.

Out of a total of about a hundred stations designed to give complete coverage for civil operations, the NATO countries will, by adopting VOR/DME, have to build only 25 new installations.

On the eve of the ICAO Council meeting, which will have to approve the text of the modifications to Annex 10, it is pertinent to draw attention to this conclusion and the patient labours of CCEA which preceded it. The decision to adopt VOR/DME did not, it is true, have a smooth passage; there were technical rivalries, national preferences and genuine implementation difficulties. But apart from the intrinsic merits of the system itself, the decision taken represents a victory for international cooperation and solidarity in the field of aviation. ⟷

The VORTAC stations in operation throughout the United States combine VOR, which supplies bearing, with TACAN, which supplies distance measurement.



For NATO: A new all-seeing eye by Autonetics

The Lockheed F-104G for the German Air Force will be able to pin-point its targets accurately in any visibility, day or night, from any altitude. The secret is NASARR—a new, extremely reliable multi-purpose radar system designed by Autonetics, a Division of North American Aviation, Inc. Lightweight, compact NASARR is the *only* system in production in the free world that is equally effective for air search, automatic tracking, air-to-ground slant ranging, ground mapping, and terrain avoidance. Already in production in the U.S.A., NASARR will now be produced in Germany.

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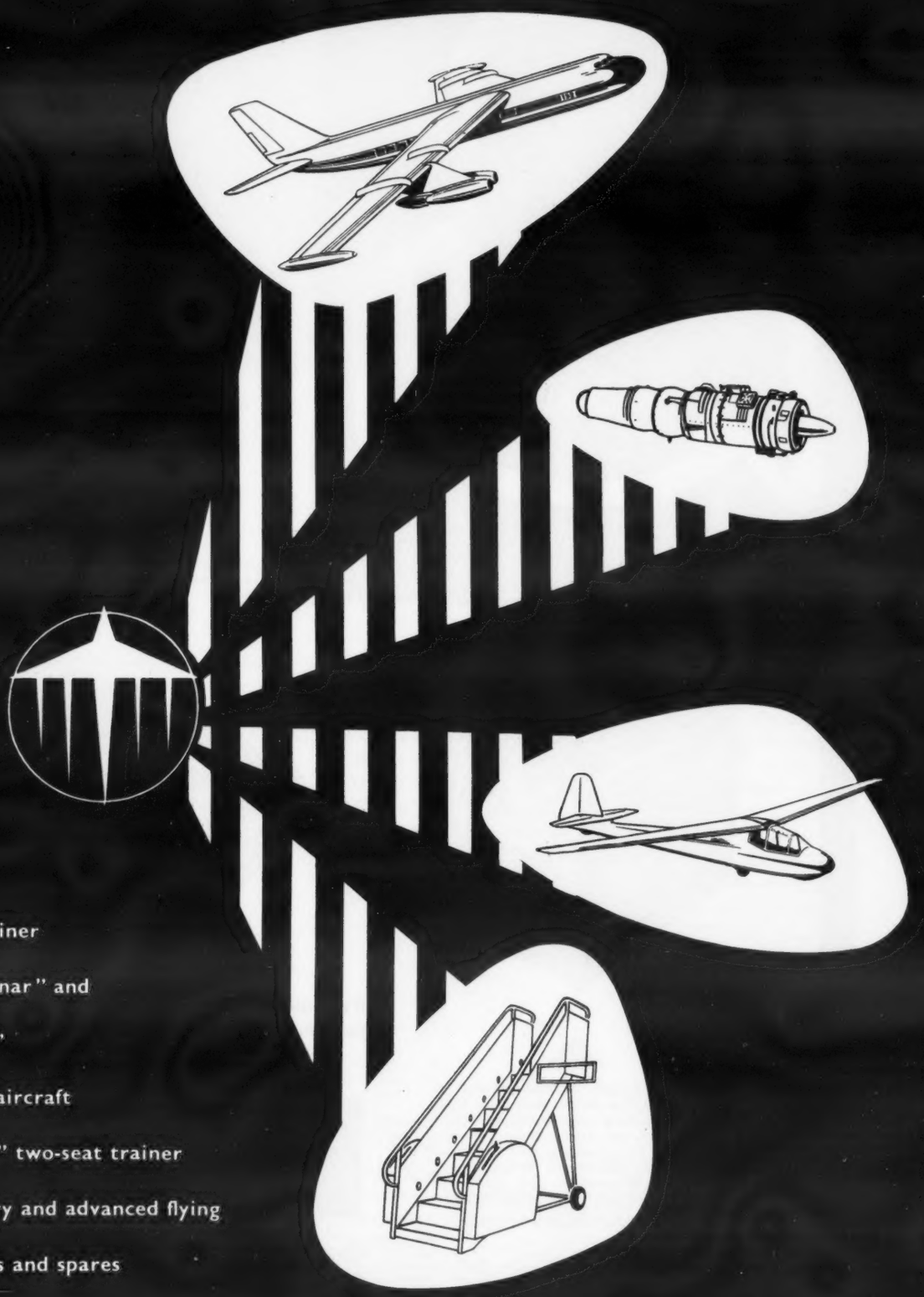

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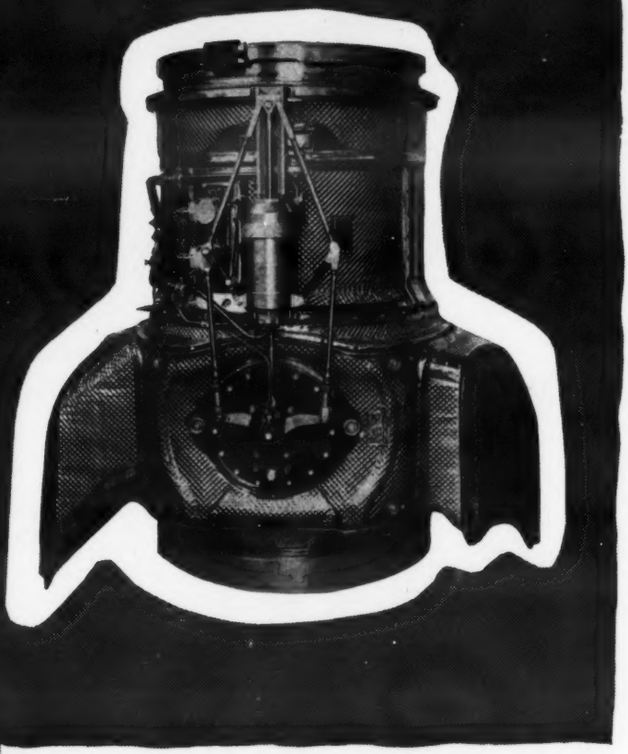

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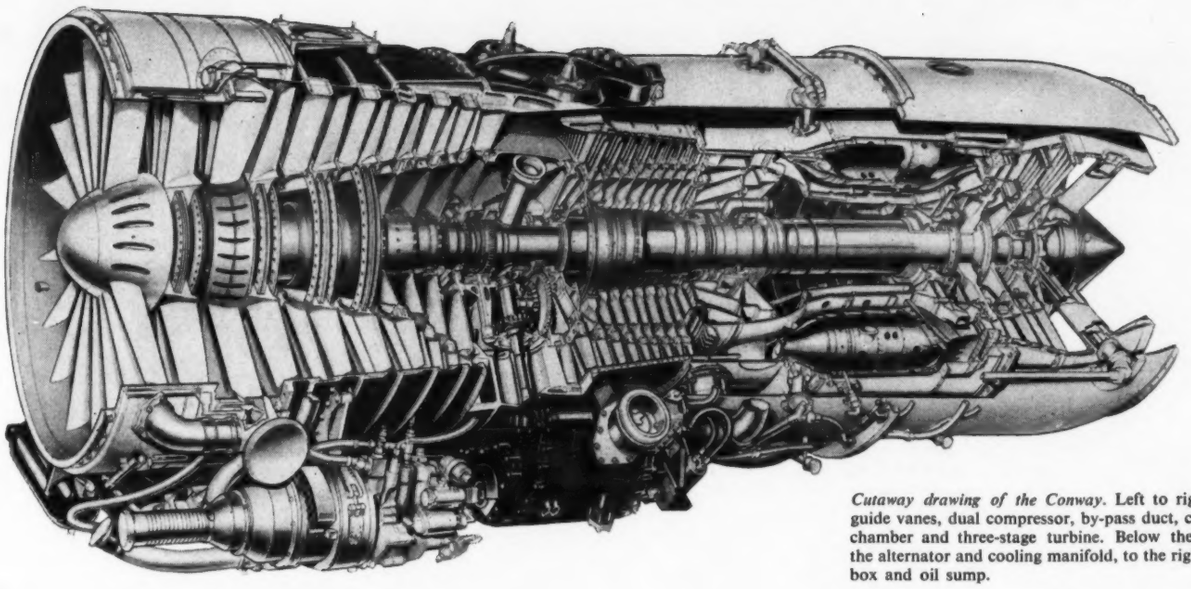


Cutaway drawing of the Conway. Left to right: intake guide vanes, dual compressor, by-pass duct, combustion chamber and three-stage turbine. Below the engine is the alternator and cooling manifold, to the right the gear box and oil sump.

Anatomy of a By-Pass Jet:

The Rolls-Royce Conway

" Burn hot and eject cool " is the thermodynamic principle behind the Rolls-Royce *Conway*. How this principle is applied in practice is shown by the accompanying drawings, photos and captions. It will be seen that a large proportion of the air flow by-passes the high pressure compressor and is not mixed with the " hot burning " primary air until it reaches the jet pipe. The mean exhaust velocity of the mixture is thus greatly slowed down, and propulsion efficiency is correspondingly increased. It will also be noted that the *Conway*, unlike the ducted fan engines with secondary fan either in front of or behind the main engine, is a true by-pass design, in which the air flow is divided inside the engine.

Development of this unusual engine began some 12 years ago (in the summer of 1948) and was originally aimed at a thrust figure of 9,250 lb. A prototype engine with the designation *Conway RCo.2* went onto the test bench four years later and made its first 25-hour run in April 1953. In the course of the next six years it was developed step by step for higher thrusts and lower specific fuel consumptions: the RCo.5 had a sea level static thrust of 13,000 lb, the RCo.8 of 14,500 lb, the RCo.12 of 18,000 lb and finally (in January 1959) the RCo.15 of 19,000 lb. A still more powerful version, the RCo.42 for a guaranteed minimum thrust of 20,000 lb, is now under development. It is scheduled to power the Vickers VC.10 and Boeing 707-520 airliners from 1962 onwards. The following table gives characteristic data for the three last-mentioned models, all of which are designed for commercial transport aircraft.

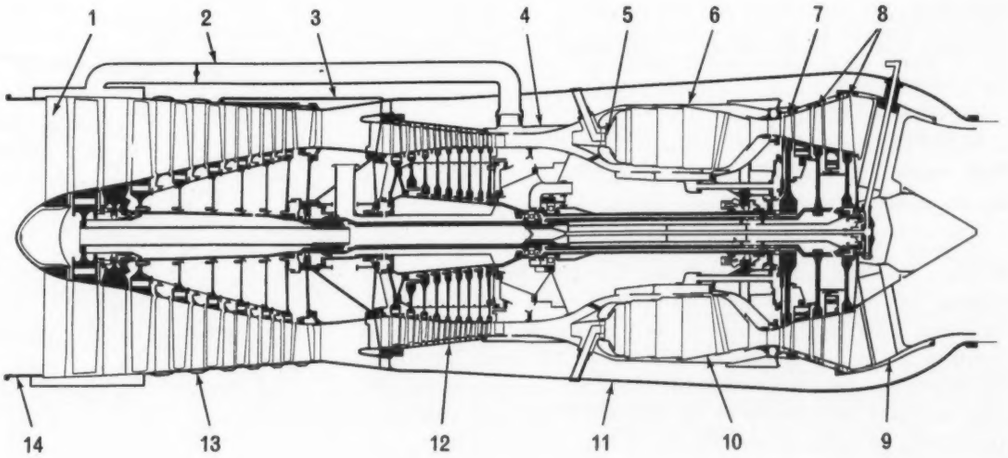
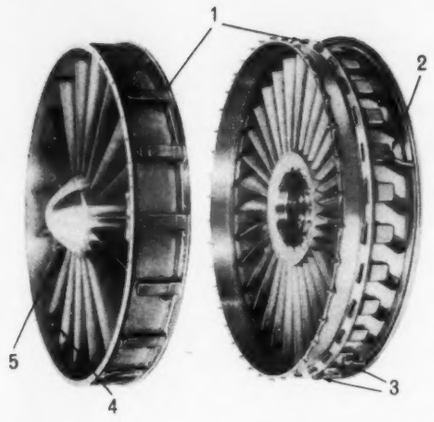
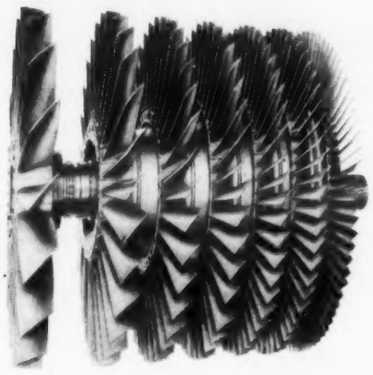


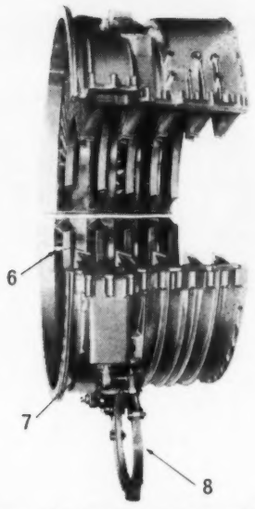
Diagram of the Conway. 1. Intake guide vanes; 2. anti-icing air manifold; 3. compressor intermediate casing; 4. compressor outlet casing; 5. fuel burner; 6. combustion chamber; 7. high pressure turbine; 8. low pressure turbines (two); 9. exhaust unit; 10. flame tubes (ten); 11. by-pass duct; 12. nine-stage high pressure compressor; 13. seven-stage low pressure compressor; 14. air intake.



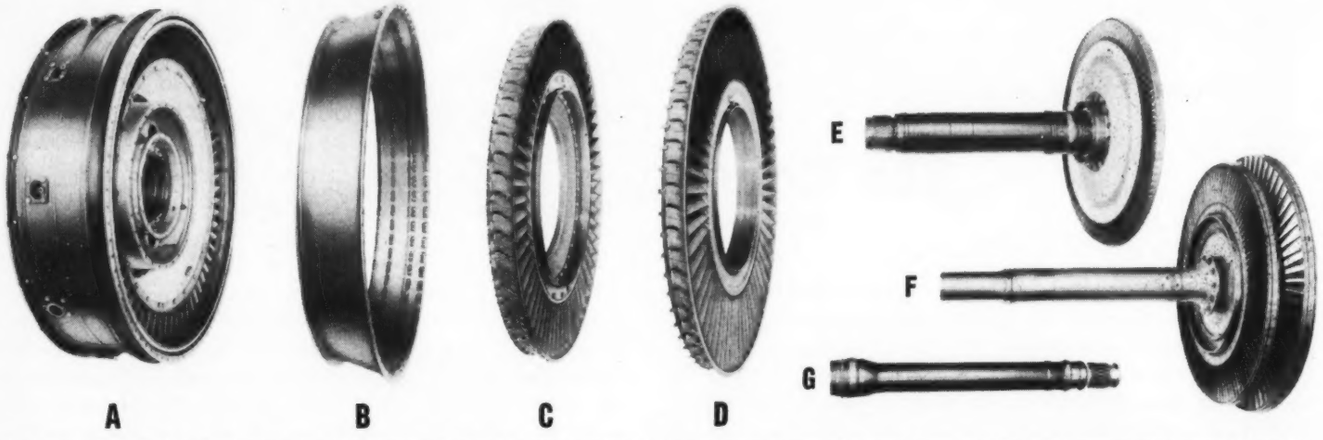
Air intake casing and first stator stage (also acting as front bearing housing). 1. Anti-icing air passages; 2. oil feed to bearing; 3. return oil from bearing; 4. air tapping from fuel control; 5. ram pressure tapping to fuel control.



Rotor of low pressure compressor: between the first and second rotor stages is the front bearing, which fits inside the first stator stage.



Two-part front casing for the compressor, with second to sixth stator stages. 6. Air bleed holes; 7. cooling air feed to alternator; 8. support manacle for Sundstrand drive unit.

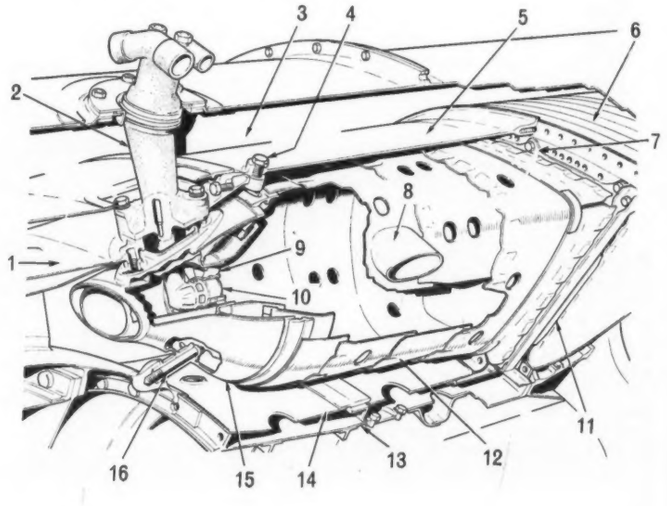


Turbine stators and wheels. Left to right: nozzle box front section and bearing housing (A), low pressure nozzle guide vane outer ring (B), low pressure guide vanes (C and D), single-stage high pressure turbine wheel with outer hollow shaft (E), two-stage low pressure turbine wheels with inner hollow shaft (F) and finally the low pressure intermediate shaft (G).

Engine type	RCo.12	RCo.15	RCo.42
Installed in	Boeing 707-420 Douglas DC-8	Douglas DC-8	Boeing 707-520 Vickers VC.10
Sea level static thrust	18,000 lb	19,000 lb	20,000 lb
Air mass flow	282 lb/sec	295 lb/sec	363 lb/sec
Fuel consumption in cruise (475 knots) at 35,000 ft	0.874 lb/lb/h	0.842 lb/lb/h	0.785 lb/lb/h
Basic weight	4,540 lb	4,580 lb	5,000 lb

Conway engines have been certificated for civil use by both Britain's Air Registration Board and the U.S. Federal Aviation Agency, and had run for more than 27,000 hours by August 1959, including 3,700 flight test hours. Test results were so good that overhaul life for the *Conway* could be set at 800 hours right from the beginning. Tests are continuing, and when the first Boeing 707-420s are taken into service by the airlines (BOAC and Lufthansa) this spring, operating hours will rise by leaps and bounds. ◆◆

Sectioned drawing of the Conway's cannular combustion chamber. 1. Main air duct; 2. fuel feed; 3. by-pass duct; 4. flame tube locating bolt; 5. combustion casing; 6. nozzle box; 7. support frame; 8. interconnector; 9. swirl vanes; 10. burner; 11. radial support bar; 12. flame tube casing; 13. intermediate casing; 14. heat shield; 15. combustion chamber head; 16. combustion chamber locating bolt.



Potez 840

A New Short and Medium Range Airliner

In May last year the management of France's Etablissements Henry Potez decided to develop a turboprop medium transport, the Potez 840, as a first venture into the civil market after a long interval. In the meantime wind tunnel measurements have been completed, and a full-size mockup has been built. A prototype is also under construction and is scheduled to begin flight testing at the end of 1960.

With four Turboméca *Astazou* turboprops of 440 h.p. take-off power each, the P.840 will be capable of a cruising speed of around 270 knots at a mean altitude of 20,000 ft; average stage lengths for economical operation will be between 270 and 810 nautical miles. Moreover special attention has been given in the design of this model to ease of maintenance, with the object of achieving minimum turnaround times.

From the structural point of view, the P.840 is based on purely conventional principles. Of all-metal construction, it has a single-spar wing with electrically operated double slotted flaps. The retractable undercarriage is of Messier design. The entire fuel supply of 350 Imp. gall. is carried in wing tanks. The pressure cabin can be fitted to seat 16 to 24 passengers, as required, and there is a 5 cu.ft. hold (also pressurized) in the fuselage rear for light cargo and baggage, as well as a smaller baggage hold in the nose If required, the P.840 will also be able to carry freight containers suspended beneath the fuselage, which will greatly improve its flexibility in handling the particularly variable payload volumes arising in short-haul traffic.

The aircraft will be operated by a crew of two and will have a relatively wide range of electronic equipment for an aircraft of its class. Planned equipment will include two VHF transmitter-receivers, a VOR and an ILS system and a highly sensitive radio compass.

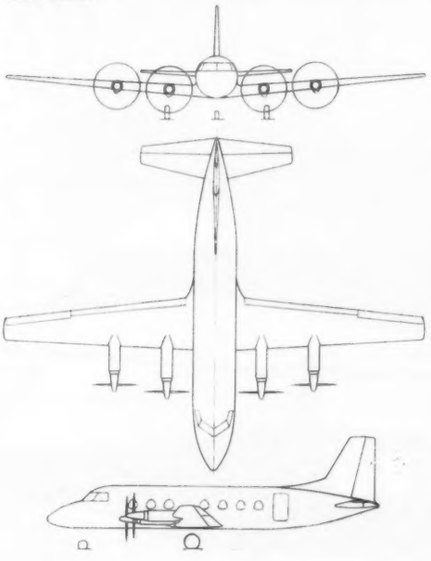
As already mentioned, the P.840 will be powered by four *Astazou* propeller turbines (with Ratier-Figeac propellers), and will thus be the first larger civil aircraft to use this engine. By the time the Potez makes its first flight the *Astazou* will have completed an impressive number of running hours on the bench. Meanwhile flight testing of the engine is being carried out on a Max Holste MH.153 converted by SFERMA of Bordeaux, and on a Nord 1110 *Noralpha*. SFERMA is also equipping a Beech *Travel Air* with *Astazous*. It is therefore legitimate to say that by the time the P.840 flies at the end of 1960 its engines will have been adequately tested.

As the aircraft manufacturing activities of Potez were taken over last year by Air Fouga, any production models of the P.840 can probably be expected to be built at the Potez-Air Fouga plant at Toulouse.

Performance data for the Potez 840

	Version for 16 passengers	*Version for 24 passengers*
Gross weight	15,390 lb	16,755 lb
Payload	3,240 lb	5,270 lb
Max. speed at 19,680 ft	approx. 280 knots	275 knots
Cruise speed at 19,680 ft	270+ knots	270 knots
Sea level rate of climb	2,124 f.p.m.	2,046 f.p.m.
Engine-out rate of climb	1,320 f.p.m.	1,260 f.p.m.
Service ceiling	23,950 ft	22,310 ft
Service ceiling, engine out	18,540 ft	16,730 ft
Take-off, sea level and 15°C (ISA conditions):		
Take-off run	1,150 ft	1,380 ft
Take-off distance over 50 ft	1,380 ft	1,640 ft
CAR 4b runway length	1,770 ft	2,100 ft
Landing distance over 50 ft, fuel down to reserves, sea level, 15°C	1,800 ft	2,030 ft

The P.840 short-to-medium-range airliner under construction at Etablissements Henry Potez has unusually clean lines. Data so far revealed are: span 63.65 ft, length 50.2 ft, height 17 ft, wing area 376.7 sq.ft., aspect ratio 10.75.



Book Reviews

Stratégie de l'âge nucléaire. — By General Pierre M. Gallois (retd.). — Preface by Raymond Aron. — Calmann-Lévy, Paris, 1960 (French; 256 pages; price NF 7.50).

The last few years have seen a flood of individual and collective calls to ban nuclear weapons. That such cries of warning are based on the loftiest of motives, that they spring from a serious concern for the fate of mankind, is beyond question. But it is doubtful whether even the most dramatic manifesto can appreciably change the course of events. If there is any way of forestalling the disaster, then it might be that proposed by the author in his study: to abandon emotional reactions which, though understandable, are doomed to remain ineffective, and replace purely moral considerations by a sober assessment of the political, military and technical facts and possibilities, be they favourable or otherwise.

It is superfluous to emphasize the author's competence to deal with his subject; for his conscientious analyses of the state of armament and the strategic concepts of both West and East will be familiar to all readers of *Interavia*. It is nevertheless pertinent to recall that General Gallois —who served with RAF Bomber Command during World War II and afterwards on the General Staff of the Armée de l'Air—joined the French delegation at SHAPE headquarters in 1954 and was partially responsible for the Western European defence plan adopted by the Atlantic Council at the end of that year.

In the five chapters of his book Gallois analyzes the historical bases, the military facts and the political and psychological chances of success of the deterrent. He comes to the conclusion that the existence of hydrogen weapons is a means of guaranteeing the maintenance of a stable and "enforced" peace . . . as long as neither camp loses its head. In his view, the hydrogen bomb is suitable not only for preventing global war, but also local conflicts, as both sides will have to reckon with the possibility that a dispute will so "exasperate" one or other of the Powers that it will resort to the use of a weapon which will annihilate both attacker and attacked.

"Whether we like it or not," concludes General Gallois, "we have entered the nuclear cycle. And we are finding that it serves a useful purpose. Or rather, it would serve a useful purpose if we understood its laws. Soviet foreign policy imposes on the West the painful duty of keeping a cool head and a heart prepared for sacrifice. There is no other way out." He.

Jane's All the World's Aircraft 1959/60.—Compiled and edited by Leonard Bridgman; assistant compiler John W. R. Taylor.—Sampson Low, Marston & Company Ltd.; London, 1959 (English; 557 pages; price £5. 5. 0).

The reader will be somewhat surprised to find that this perennially youthful work of reference is already fifty years old. In a preface, Oliver Stewart gives an appreciation of the work of its three editors: Fred T. Jane (1909-1916), Charles G. Grey (1916-1940) and Leonard Bridgman, who assumed the editorship in 1940 and is now retiring. Sixteen pages are devoted to reproductions from the first edition, which bore the title "All the World's Air-Ships (Flying Annual)"; even then the names of Handley Page, A. V. Roe, Short Bros. and Breguet were prominent. There is also a chronology of 1909, listing the aviation events of that year.

The presentation of the jubilee issue is better and more comprehensive than ever. The descriptions of aircraft, arranged according to country and manufacturer, contain 866 illustrations (of which 499 are new) and cover 403 pages; engine descriptions contain 171 illustrations (96 new) and cover 95 pages; and guided missile descriptions with 94 illustrations (59 new) cover no less than 50 pages. Under the heading "First Flights" a total of 86 first flights of protypes, production aircraft and new versions is recorded for the period September 1st, 1958 to August 31st, 1959.

New features of the fiftieth anniversary Jane's include sections on Mexico and the People's Republic of China, Soviet satellites and payload capsules, and a large number of American racing aircraft. The sections on airlines of the world and military aircraft markings have been dropped. Jane's is too well known to need further recommendation, for it is indispensable to every aviation library. De.

Le Vol des Avions. — By Jean Renaudie. Presses Universitaires de France, Paris, 1959 (French, 127 pages).

After a multitude of other works on aeronautics, all of them characterized by a thorough study of the facts and an admirable clarity of presentation, the "Que sais-je?" series has given us a new volume in every respect worthy of its predecessors. A mass of invaluable data, clearly illustrated by sketches, diagrams and tables, free of burdensome mathematical trappings, such is a definition of this book. The author presents the aircraft, the environment in which it moves, the stresses to which it is subjected, the conditions of flight, manœuvres and, finally, the conquest of space. In short, these 127 pages serve as an introduction for the layman and a refresher for the specialist. Ka.

Jahrbuch der Luftfahrt 1960 (9. Auflage). — Edited by Karl-Ferdinand Reuss. — Südwestdeutsche Verlagsanstalt GmbH, Mannheim, 1959 (German; 416 pages; plastic-bound; price DM 14.80).

The ninth edition of this aviation address and reference book, which appeared for the first time in 1951, is about 50 pages longer than last year. The editor is also known for his work on the "Wegerdt-Reuss, Deutsche Luftfahrtgesetzgebung" series of texts. Clearly set out, the year-book has a thumb index to indicate international organizations and the most important branches of aviation in the German-speaking countries: air law, national and local authorities, research, air transport, industry, sports flying, aviation press, civil defence, etc.—Alphabetical register of firms, index of products, register of aviation personalities. He.

Squadron Histories, R.F.C., R.N.A.S. & R.A.F., 1912-1959. By Peter Lewis. Putnam & Company Limited, London, 1959 (English; 208 pages; 8 colour plates; price 30 shillings).

As the author points out in his introduction, over 540 squadrons have been formed since the earliest days of the Royal Flying Corps and the Royal Naval Air Service. His "histories" have therefore had to be confined to brief notes on date of formation, equipment flown, major stations, etc. Nevertheless this forms a valuable reference book for all those who are historically minded. The main text is supplemented by eight full-colour plates showing fighter squadron markings and by appendices listing aircraft specifications, titles of squadrons, approximate strengths, Chiefs of Air Staff, Secretaries of State for Air, comparative ranks in the British services, and many other details. St.

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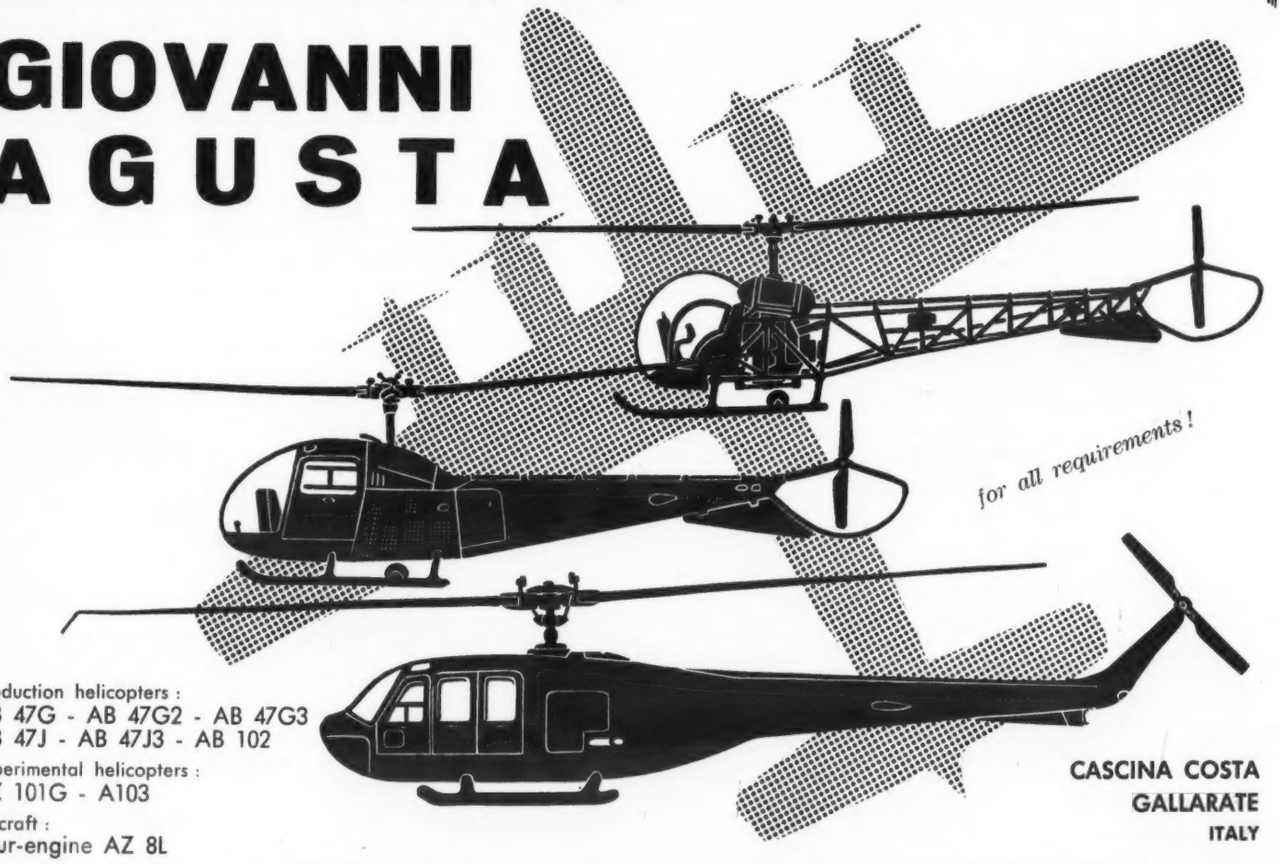

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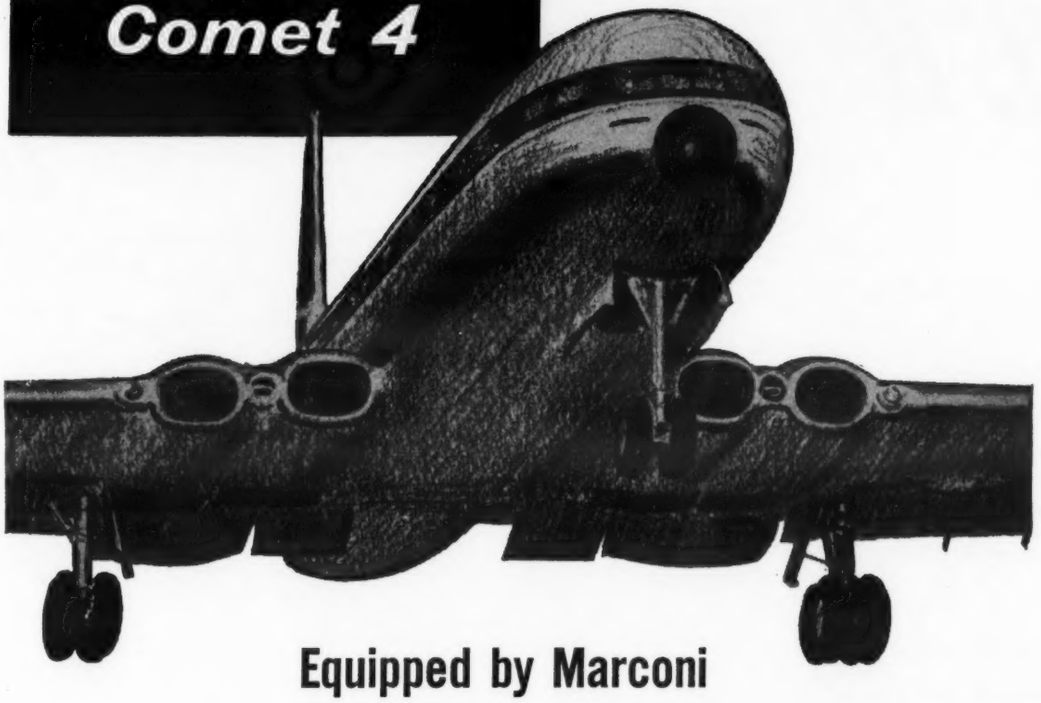

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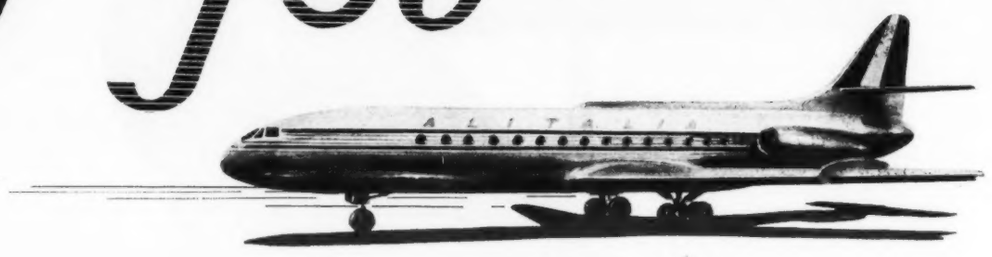

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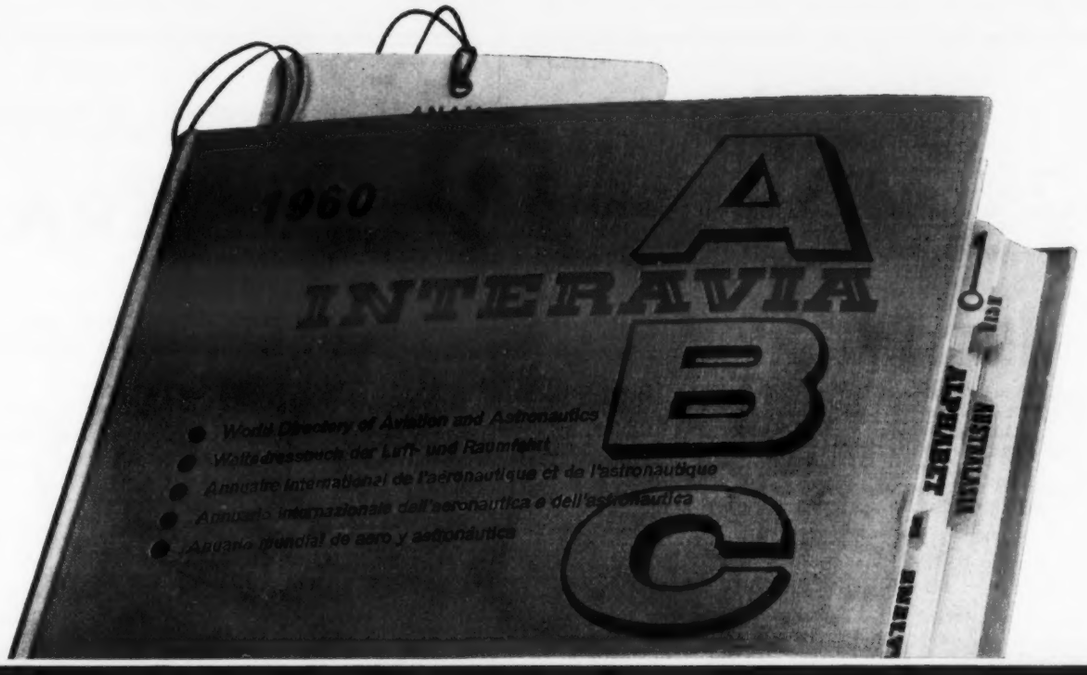

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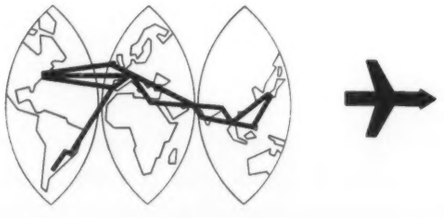

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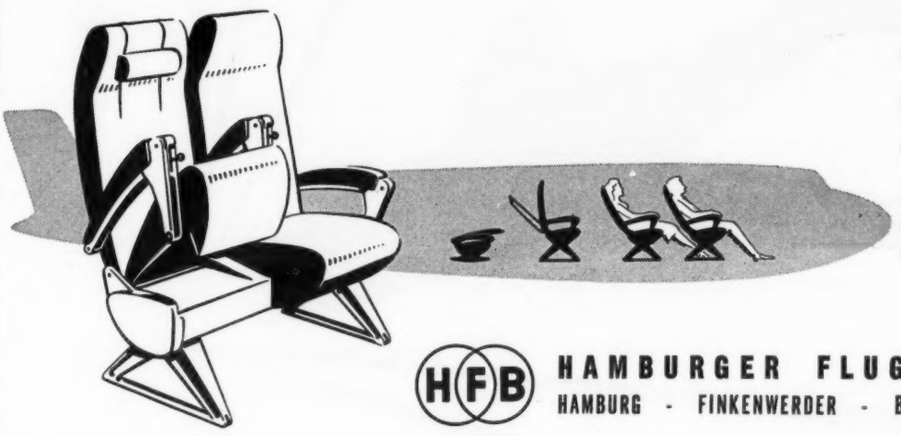

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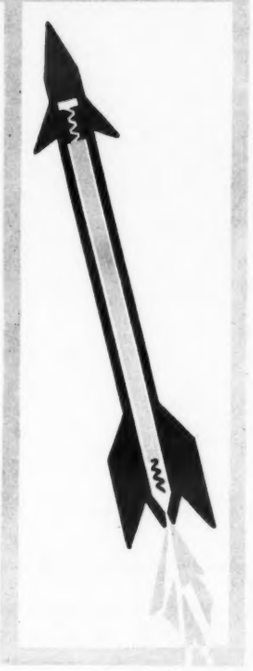

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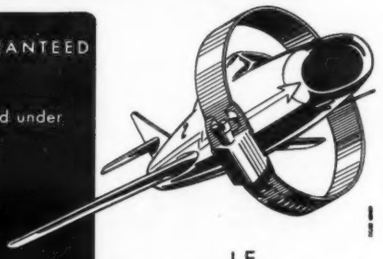

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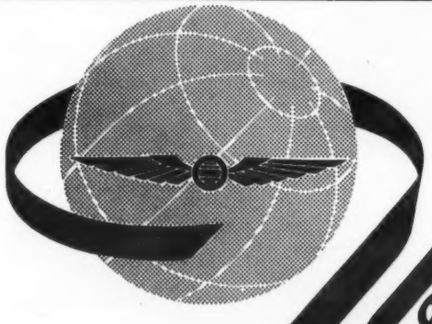

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